ith the Compliments of the Director.

ANNUAL REPORT

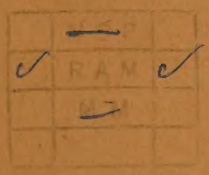
OF THE

INDIAN INSTITUTE OF SUGARCANE RESEARCH
LUCKNOW

—

1961-62

GOVERNMENT OF INDIA
MINISTRY OF FOOD & AGRICULTURE
(DEPARTMENT OF AGRICULTURE)



THE REPORT OF THE DIRECTOR

I have great pleasure in submitting the annual progress report of the Indian Institute of Sugarcane Research for the year 1961-62. The Institute was established at Lucknow in 1952 for conducting researches on the more fundamental aspects of sugarcane research and for the co-ordination of sugarcane researches done in India. This is the 8th annual report of the Institute, and the second one based on the programme drawn up in 1960.

Administration and general

All the seven sections of the Institute, namely Agronomy, Agricultural Chemistry and Soil Science, Physiology, Agricultural Engineering, Mycology, Entomology and Administration, besides the subsections of Statistics, Library, Artists and Farm continued to function during the year. The names of the officers in charge of the sections are given on page 8 and the research programmes for 1961-62 on page 10 . The total sanctioned strength of the Institute during the year was 11 officers, and 170 assistants and other subordinate staff, as against 13 and 184 in the previous year.

In addition to the programme of the Institute, the following five ad hoc projects financed by the Indian Central Sugarcane Committee continued to be implemented at the Institute during the year.

1. All-India Coordinated Scheme for Research on the Control of Rust disease.

2. Scheme of Entomological Outposts.

3. Scheme for Coordination of Research work on Insect pests.

4. Scheme for Studies on the physical and chemical Criteria of Gur, leading to the formulation of basis of gur grades.

5. Scheme for Researches on the Storage of Gur.

In the Scheme for Entomological Outposts, the 4 Outposts established earlier were continued, but the fifth one for Assam could not be established due to reduction of grant by the Indian Central Sugarcane Committee. The Scheme for Coordination of Research work on Insect pests terminated on 28th February 1962 consequent on the decision of the Indian Central Sugarcane Committee to decentralise the work. In these 5 schemes, the staff strength in 1961-62 was 2 officers, and 31 assistants and other staff, as against the sanctioned 2 officers and 32 assistants and other staff in 1960-61.

The budget of the Institute for the financial year 1961-62 was Rs.6,36,000. In addition, Rs.50,000 was sanctioned and utilized during the year as capital expenditure. The aggregate grant of the five schemes financed by the Indian Central Sugarcane Committee was Rs.1,36,000. The total budget of the Institute was thus Rs.8,22,000 as against Rs.9,47,000 during 1960-61.

The income of the Institute during the year was approximately Rs.1,17,000; this was comprised almost entirely of receipts from sale of farm produce.

A mango-orchard of 81 trees has been planted during the year, utilizing about 0.93 hectare of land which could not be utilized for crops. Ninety other trees were also planted.

A 6-day refresher course in Plant Nematology was conducted at the Institute by the Mycologist, Dr. Kishan Singh from 9th to 14th

October 1961. It was attended by 9 trainees from different States and the Centre.

The area under sugarcane (experiments) was about 34 hectares, including 7 hectares under ratoons. Plantings were timely and good; but irrigation was greatly restricted due to irregular supply from the canal. Nor was the weather very favourable. The summer was severe and dry; the monsoon was late by about 2 weeks, and started with a downpour of 126 mm on 10th July 1961. Frequent heavy rains during the monsoon also caused repeated waterlogging. At the closure of the monsoon again, about 250 mm of rain was received, and this was accompanied by cyclonic winds. The total rainfall (1,341 mm) exceeded the normal by about 300 mm. The crop also lodged badly, and the resultant loss in weight was heavy. The average yield of cane was thus reduced to 38 metric tons per hectare, no allowance being made for paths, channels and blank rows left in the experimental fields.

Research Results

There was a sharp increase in the tempo of research during the year, and many relatively important advances were made. In the Agronomy Section, following upon the several detailed studies on the germination, viz. census, bud-interactions, effects of dryage and soaking, etc. investigations were continued in 1961-62 on the viability gradients of buds on the cane-stalk as affected by its being cut into 3-budded setts, and on the relationship between loss of moisture from setts and the germination of planted setts. From all studies so far carried out at this Institute, it appears that in north India the moisture status of setts is the principal and primary determinant of the speed of germination. Germination is delayed by loss of moisture even in comparatively unripe cane. On the other hand, each quantum of moisture-conservation in setts brings about a corresponding improvement in germination velocity. The possible utility of moisture-proof storage and moisture-proofing of setts was therefore assessed; these studies were very fruitful. These investigations were supplemented by studies in the Physiology Section (q.v.) on the precise internal and external conditions favouring or retarding germination.

Gradients of the cane stalk, so effective on germination capacity, were not noticeable in the dry weights of clumps from the successive buds. Within limits, the length and thickness of the full (uncut) internodes of 3-budded setts were not correlated with the weight of the clump arising from the middle bud. Tiller census studies indicated that large reductions in seed rate could be made in autumn-planted and other long-season cane.

One of the most revealing results obtained during the year was that with cane setts planted in November, an increase in ground area per clump caused the individual clump, on the average, to tiller more, and carry more canes to harvest. Treatments with reduced seed rates had larger stalk populations per hectare and individual stalks being heavier the yields per hectare were distinctly more. The two varieties used in this experiment did not react in the same manner to increases in absolute spacing, but the ultimate result was similar.

The studies on germination and moisture conservation in soil have led to the evolution of a new technique of cane planting wherein sugarcane plants are developed in nurseries under transparent polyethylene film cover and transplanted after a 4-6 weeks growth. The special feature of this technique is that it furnishes the seed the needed optimum temperature and humidity conditions for its germination even when the external conditions are extremely unfavourable. It also provides for a high degree of control over other aspects of germination. The technique which gives 80-100 per cent germination is of special significance to north Indian areas, where due to low temperatures, low humidi-

ties and low soil moisture, germination is usually only about 30-40 per cent. Transplantation is entirely successful. The technique ensures a gapless stand, earlier tillering, a longer period of growth and comparative immunity from termite attack and clump-failure. A proper development of this technique may lead to substantial economies in expenditure and increases in production. A preliminary test of germinations in various types of setts in the nursery showed high sprouting in all, but the growth of sprouts was best in 3-budded setts and in the nodal-cut material.

A third important finding, based on observations of moisture relationships in soils and root activity of cane, was that in alkaline soils, the yields could be raised strikingly by laying trash-veins in the planted furrows. In the microplot experiment conducted, such moisture conservation promoted shoot production and linear growth; and the yield was 105 per cent above the control.

In weed control trials, Simazin gave a better over-all effect, but the best kill of Johnson grass was with Telvar. Dowpon kept Cyperus rotundus in check and also reduced Johnson grass, but caused yellowing of the cane crop and brought down its yields.

In studies to decipher the progress of ripening in the cane stalk, it was observed that the winter temperatures of north India either slowed down or reversed the progress of ripening; further, the response of the different parts of the cane stalk to seasonal conditions was according to their position on the cane stalk. Due to this differential response during this year of severe cold wave, in the later part of the season, the highest pols were in the successively higher portions of the stalk, the reverse of what is popularly believed to be the case.

A study of results of experiments in various States showed that intercropping of autumn-planted cane with other crops causes an improvement in the juice-quality without an increase in fibre content.

Experiments to assess the possibilities of sugarbeet cultivation were continued. Sowings were unfortunately delayed by heavy rains at Lucknow in early October, and the seed, being old, gave very defective germination. Even so, two varieties US.35 and US.75 produced about 27 metric tons of roots per hectare and Ramonskaya over 20 metric tons. US.35 was earlier in ripening than the others; all the varieties tried had between 17 and 18 per cent pol in roots in May. Sugarbeet seed seems to need very high moisture in soil for its germination; and the experiment on irrigation showed that the crop also responds well to irrigation. An important finding was that roots of transplanted seedlings were bigger than those of seed dibbled directly, and the yields were higher. Collaborative trials were carried out by State Research Stations at Jullundur, Karnal, Muzaffarnagar, Shahjahanpur, Gorakhpur, Pusa and Mandya, and small-scale tests at 17 other centres.

The sugarbeet work has now been discontinued. The overall results showed that this crop could be raised in north India quite successfully, and that very good yields, comparable with European averages, could be obtained by employing techniques suited to Indian conditions.

In the Agricultural Chemistry and Soil Science Section, the analysis of soils from selected plots of a long-term experiment from the Sugarcane Research Station, Muzaffarnagar showed that chemically the soil had not improved to any appreciable extent by the continuous application of farmyard manure, nor had the fertility of the ammonium sulphate-treated plots gone down appreciably. Soil aggregation in the former was not more than that of the latter. A critical evaluation of

green manuring experiments conducted between 1939 and 1961 at the Sugarcane Research Stations at Shahjahanpur, Muzaffarnagar, Jullundur, and the Government Farms at Mainpuri and Kalai suggests that a leguminous crop grown during the monsoon for fodder or other use may be nearly as effective as green manuring for raising the yield of cane.

Uptake of phosphorus by sugarcane from nitrophosphates and superphosphate did not show variation due to either dosage, method of application or level of N. In cane plants raised with phosphorus-deficiency, the top four internodes were found to be the best indicative tissue for phosphorus.

In soil microbiological investigations, the antagonistic effect of B. subtilis on Azotobacter vinelandii, seems to be due to an excretory product of the bacterium.

In the Physiology Section, experiments on the prevention of flowering in six varieties have indicated that a total suppression of flowering can be achieved in all of them by defoliating the stalks in the 2nd or 3rd week of September. This defoliation seems to have no effect on cane yield. Neither maleic hydrazide nor naphthalene acetic acid sprayed at 4.5 kg. per hectare in September had any effect on the flowering of Co.1207; but cobaltous nitrate at 2.25 kg. per hectare had.

Studies on the internal and external conditions of germination have shown that setts normally possess enough moisture for the germination of their buds. Supply of additional water to setts not only improved the germination of the buds and growth of shoots, but markedly increased root production.

A very important finding was that both buds and root-primordia can germinate and grow when the relative humidity around the sett is about 96 per cent, but at 85 per cent, only buds can germinate.

In the Agricultural Engineering Section after many efforts, a satisfactory furrower for sugarcane planting was fabricated. In well-tilled soil the prototype could make furrows 150 mm deep. Efforts are now being made to reduce the draft.

A new manual tool for stripping cane stalks for factory-supply or gur-making has been designed. It is expected that with this tool cane stalks can be detrashed faster than with a sickle.

A tractor-drawn implement for applying liquids below the soil level at predetermined quantities and depths by gravity-feed was designed and fabricated. Modifications are now on hand for controlling the application by the ground speed of the tractor.

A new venture of the Engineering Section was a technique of mechanised sugarcane culture in which seed-bed preparation is limited to ripping and rotovation in the lines where cane is to be planted. This restricted cultivation favourably affected the spread of irrigation water and the distribution of roots, while reducing the costs of cultivation; yields were not affected.

A precision soil sampler which extracts a clean core of soil without disturbing the successive layers of topsoil has been designed and perfected. This is likely to be of very special use in soil-microbiological, nematological and other studies requiring precise samples of soil with the natural stratification intact.

A gur hardness-testing apparatus has been designed and fabricated for use in gur research.

Following on the findings of the Gur Storage Scheme on the external and internal conditions of gur preservation, the Engineering Section has designed a gur-storage godown; this is based on the principle of minimising the moisture content of stored gur before the onset of the monsoon, reducing the temperature, and moderating its variation within the godown. It employs no air-conditioning, but merely appropriate construction materials, and purports to improve the storage conditions and quality of gur by utilizing the normal weather conditions to best advantage.

In the Mycology Section further improvements were made in the technique of inoculating red rot in stalks. The variation in lesion length in inoculated stalks could not be accounted to the age of stalks. Isolates differed in the linear spread of symptoms produced by them. The degree of sporulation on the artificial medium was found to be no indication of the virulence of an isolate, as commonly believed. A satisfactory technique of nodal infection for red rot has been worked out.

In the presence of red rot, the wilt fungus was found to be capable of progressing within a stalk to a greater extent than when alone. The spread of the wilt fungus was farther than the visual symptoms of the tissues indicated.

An inoculation technique for inciting smut disease in cane for the purposes of varietal screening and various pathological experiments has been worked out. The technique is based on the principle of placing the spores on the inner bud scales. It gives higher incidence and was more efficient than the existing method.

In investigations under the Rust Scheme rust cultures of Co.419 Lucknow have now been maintained under laboratory conditions for 52 generations. For adult resistance trials in the field, the inoculation-technique evolved has not been as successful as the laboratory cut-leaf technique. A clone of Saccharum spontaneum S.E.S.66 when inoculated took infection of the rust of Co.419 at Lucknow; this indicates the possibility of certain clones of spontaneum acting as collateral hosts in India. Another important new finding is the existence of at least two distinct physiologic races in the sugarcane rust organism.

The survey of plant parasitic nematodes in sugarcane areas was continued. From the samples so far analysed at this Institute, these parasites seem to be prevalent in areas in Punjab, Uttar Pradesh, Bihar, Madhya Pradesh and Madras States. In a collaborative pilot experiment at Sugarcane Research Station, Jullundur, the two nematicides used brought down the nematode populations temporarily and gave marked increases in the yield of cane. The root systems of plants in nematicide-treated plots were also better.

In the Entomology Section, considerable progress has been made in studies on the toxicity and persistence of insecticides. Gamma BHC, aldrin and heptachlor gave good control of shoot borer, but foliar sprays of systemic insecticides (thiometon, metasystox and gusathion) were not effective. For the control of stalk borer, spraying of 0.1 per cent emulsion of endrin 3 times from September to November was better than the other treatments tried.

Soaking of seed-cane for two hours in gamma BHC + DDT, diazinon, telodrin or in malathion resulted in high mortality of the larvae and pupae of Chilotraea auricilia Ddgn. within the canes; the germination of the buds was not affected.

An important observation on the biology of borers was that the grown-up larvae of the first brood of C. auricilia migrated to

ratoon stubbles towards end-April, and pupated there in the latter half of May, the moths emerging in June. This (under central U.P. conditions at any rate) dispels the belief that there are two broods of this pest between February and June.

Another interesting finding was that the resistance shown by varieties to top borer attack was partly accountable to their vigour of growth. Stalks of such varieties could throw out the attacking top borer larvae before the latter could reach the growing point. Such penetration failures were more in the autumn-planted crop than in the spring-planted ones or ratoons.

Among the broods of top borer, the third one caused the worst damage, because the number of stalks attacked was also the maximum and the growth of the attacked individual shoots was arrested to the extent of 70 per cent on the average. The stalks attacked by the 4th brood were only 5 per cent less in weight than unattacked canes, while the 5th brood larvae caused no material losses, because by then, the crop had attained full growth. In juice-quality also, the 3rd brood brought about more deterioration than the later ones.

A new bethylid parasite, Parasierola sp. was recorded on the caterpillars of the army worm, Pseudaletia (Cirphis) unipuncta Haw. Studies on certain Hymenopterous parasites of moth-borer larvae are continuing. In the Sehore area of Madhya Pradesh a fungal parasite, Metarrhizium anisopliae Metsch. appears to be well established on Pyrilla and is able to control this pest more rapidly, than Epipyrops malenoleuca a common parasite of Pyrilla of Uttar Pradesh.

Insect pest surveys have made steady progress in the Entomological Outposts Scheme. In addition to the general information regarding the distribution, spread and intensity of incidence of various pests and their climatic relationships, many facts have been revealed which may be of significance to the sugarcane industry. One important new observation is that the common shoot borer known to be active only in the hot weather and only on the young crop, also acts as a cane borer in some parts of Rajasthan and Orissa; it is thus active there almost throughout the year. The Gurdaspur borer has now been collected from as far south as Sriganganagar; a close watch on this pest as also on other borers is necessary in Rajasthan, where conditions appear to be favourable for many species. Another prospectively important indication is the emergence of beetle grubs as a serious pest of sugarcane. A beetle grub, Lachnosterna consanguinea was first observed in 1956 in the Dalmianagar zone of Bihar, causing considerable damage where it occurred. The life history and biology of this beetle were worked out at this Institute and control measures evolved. In 1962, beetle grubs were reported damaging cane in Bulandshahr. The Outpost surveys have now reported beetle grubs in Sriganganagar and Udaipur in Rajasthan, and at Rayagada in Orissa; more recently also in Hospet in Mysore State. Whether all these belong to the same species is under study. Control measures as worked out for Lachnosterna consanguinea are being suggested in latter cases.

In a termite control experiment carried out at Rayagada, aldrin applied in furrows with planted setts gave good control. In another experiment the planting of nursery-raised slip-setts with germinated shoots appeared to be much less preferred by termites than ordinary setts.

A number of parasites of sugarcane pests have been collected at the various Outposts. In some cases, the natural parasitisation has been found to be as high as 30 per cent. The wasp, Isotima javensis (Melcha ornatipennis) released in the Vadapathimangalam area seems to have established itself there as a parasite on the top borer. Certain other parasites are being reared and their release is being studied.

In the Gur Grading Scheme, a standard method for determining the keeping quality of gur has been developed, and colour standards for grading have been prepared. One important finding was that the addition of "hydros" markedly increases the sulphur dioxide content of gur; a number of samples collected in the markets of various States had a high content of sulphur dioxide, in some cases presumably due to hydros, and in others possibly due to the admixture of sulphitation khandsari molasses with cane juice. This requires investigation.

Among the findings of the Gur Storage Scheme, one is that gur undergoes inversion during storage only when its initial moisture exceeds 8 per cent. It was confirmed that 58 per cent is a safe level of atmospheric humidity for the storage of gur.

Comparative studies were made of gur storage conditions in four of the principal mandies in India, — Rajahmundry, Kolhapur, Dankaur and Muzaffarnagar. These suggest that in prolonged moist weather, stored gur absorbs moisture at all the places. At all places, the stored commodity was withdrawn by the trade before the gur was damaged; and this was likely to increase the deterioration of what was left. At Rajahmundry, repeated paddy-husk smoke-treatment helped to check the spoilage.

Effects of pressure on gur were determined in the laboratory; gur kept at 72 per cent humidity collapsed within 4 days, while that kept in a drier atmosphere stood the same pressure without disintegration. Another finding was that, within limits, good gur and bad gur absorbed moisture more or less at the same rate; the difference was that while the former could hold the absorbed moisture, in the latter, it liquefied the invert sugar which thereupon started to drain away.

The work of the year has produced a considerable amount of information not known before, and opened out many new lines. These are being followed up.

Respectfully submitted.

Director.

Lucknow
April 15, 1963.

STAFF

Director	Shri R.R. Panje.

AGRONOMY

i) Research

Assistant Agronomist	Shri P.S. Gill.
Research Assistant	" Masood Alam.
Research Assistant	" M.P. Motiwale.
Research Assistant (Chemical)	" Bakhtawar Singh.
Scientific Assistant	" S.R. Seth.
Scientific Assistant	" J.P. Misra.
Scientific Assistant	" K.C. Pathak.

ii) Farm and General

Farm Superintendent	" Suba Singh.
Assistant Farm Superintendent	" Rajendra Singh. (till 8th January 1962)
	" B.S. Hora. (from 9th January 1962)
Agricultural Inspector	" B.S. Hora. (till 8th January 1962)
Agricultural Inspector	" M.P. Kanaujia.
Agricultural Inspector	" Ranvir Singh.
Draftsman	" S.P. Nigam.

iii) Statistics

Statistical Assistant	" R.S. Srivastava.
Computor	" S.B. Lal Shukla.

AGRICULTURAL CHEMISTRY & SOIL SCIENCE

Soil Chemist	Dr. Ambika Singh.
Senior Chemical Assistant	Shri S.N. Pandit.
Senior Soil Assistant	" S.S. Iyer. (till 30th March 1962)
Senior Microbiological Assistant	" D.P. Johari.
Junior Chemical Assistant	" S.M.H. Jafri. (from 1st June 1961 till 23rd April 1962)
Junior Chemical Assistant	" Ranjit Singh.

PHYSIOLOGY

Physiologist	Dr. T. Raja Rao.
Senior Physiological Assistant	Shri K.K. Srivastava.

AGRICULTURAL ENGINEERING

Agricultural Engineer	Shri R.G. Menon.
Assistant Agricultural Engineer	" A. Subrahmanyam Iyer.
Engineering Research Assistant	" K.N. Lahiri.
Senior Draftsman	" B.K. Dutta.
Mechanic	" Inder Singh.

MYCOLOGY

Mycologist	Dr. Kishan Singh.
Assistant Mycologist	Shri C.L. Subramanian.
Research Assistant	" V.B. Singh. (till 5th July 1961)

Research Assistant	Shri	M.B. Singh. (from 7th March 1962)
Research Assistant	"	T.R. Budhraja.
Scientific Assistant	"	S.P. Dwivedi.

ENTOMOLOGY

Entomologist	"	A.N. Kalra.
Assistant Entomologist	"	P.N. Avasthy.
Research Assistant	"	M.C. Gupta.
Research Assistant	"	J.P. Chaudhary. (from 1st July 1961)
Scientific Assistant	"	R.C. Srivastava. (from 22nd September 1961)
Setter and Pinner	"	Tribhoki Nath.

ARTISTS

Senior Artist-cum-Photographer	"	A.M. Das.
Photographer-cum-Artist	"	S.K. Sharma.

ADMINISTRATION

Administrative Officer	"	A.S. Charan.
Office Superintendent (A)	"	R.A. Singh.
Office Superintendent (E)	"	B.N. Sharma.
Confidential Assistant	"	H.L. Khanna.
Librarian	"	P.D. Pathak.

TECHNICAL PROGRAMME FOR 1961-62

Agronomy Sugarcane

1. Studies in germination.

   i) Gradients and interactions in the germination of buds.

   ii) Influence of length and thickness of setts on their germination capacity.

   iii) Effects of keeping seedcane before planting.

   iv) On the optimum period of keeping setts before planting.

   v) Effects of moisture depletion and moisture conservation in setts.

   vi) Effects of removal of green blades of standing cane before harvest.

   vii) Estimate of loss in weight through various surfaces of a 3-budded sett.

   viii) Estimate of the loss in weight of setts planted in soil.

   ix) Effect of certain moisture-proofing materials on loss of weight of setts.

   x) Effect of dipping setts in waxol on the germination of buds.

   xi) Effect of shellac-coating of setts on the germination of buds.

   xii) Effect of application of aretan in different ways on the germination of buds.

   xiii) Effect of BSM-11 on the germination of buds.

   xiv) Effect of spray irrigation of cane crop on the viability of seedcane.

   xv) Effect of thickness and compaction of soil cover on the emergence of germinated shoots.

2. Studies in tillering.

   i) Gradients in tillering.

   ii) Relationship between the dimensions of the internodes and the weight of the clump.

   iii) Plant density in relation to seed-rate in autumn-planted sugarcane.

   iv) On the absolute spatial relationships of cane clumps.

3. Studies on conservation of moisture for sugarcane crops.

   On the use of soil cover and trash veins in alkaline soils.

4. Studies on cultural systems and practices for sugarcane.

   The polyethylene nursery system of raising sugarcane crop under north Indian conditions.

5. Studies on the control of weeds in sugarcane fields.

i) On the effect of Dowpon application in the field at different stages of crop-growth.

ii) On the comparative efficiency of certain herbicides.

6. Fertilisers and manures.

i) Comparative efficiency of certain fertilisers and manures for sugarcane.

ii) Comparison of nitrophosphate manufactured by O.D.D.A. and P.E.C. processes at different levels and applied to sugarcane crop by different methods.

7. Studies in the ripening of sugarcane.

i) Progress of ripening in cane stalks.

ii) A review of the influence of intercrops on the juice-quality of sugarcane.

8. Miscellaneous.

i) Seedlings.

ii) Preliminary test of seedling varieties 1960-batch.

iii) Final test plot.

iv) Trial of varieties.

v) New arrivals.

vi) Live herbarium.

Sugarbeet

i) Trial of sugarbeet varieties.

ii) Nitrogenous-fertiliser requirements of sugarbeet.

iii) Irrigational requirements of sugarbeet.

iv) On seed production.

v) Comparison of different cultural methods for raising sugarbeet crops.

vi) The relationship between soil moisture content and germination of seed balls.

vii) Co-ordinated trials at various centres in India.

Agricultural Chemistry and Soil Science

1. Studies on the modus operandi of green manure.

2. Comparative cumulative effects of manures and chemical fertilisers on sugarcane crop and soil.

3. Soil-plant relationship of potassium in sugarcane soils of India.

4. Nutritional studies on sugarcane.

5. Studies on nitrogen-transformation in sugarcane soils.

Physiology

1. Studies on the prevention of flowering.

   i) Effect of defoliation on the flowering, cane yield and juice-quality of varieties Co.1207 and Co.1062.

   ii) Effect of defoliation on the flowering of different varieties.

   iii) Effect of maleic hydrazide & N.A.A. on the flowering of Co.1207.

   iv) Effect of cobaltous nitrate on the flowering of Co.1207.

2. Studies on germination.

   i) Effect of preventing loss of moisture from setts on germination.

   ii) Effect of increasing the moisture content of setts on germination.

   iii) The influence of bud on the growth of root primordia.

   iv) The effect of relative humidity of the surrounding atmosphere on the germination of buds.

3. Biochemical basis of resistance to red rot.

Agricultural Engineering

1. Study and improvement of agricultural implements at present used for sugarcane cultivation in different regions.

2. Field testing of sugarcane implements designed and manufactured in the country by private agencies or imported from abroad.

3. Designing and fabricating improved bullock-drawn and tractor-drawn implements and other machinery for sugarcane cultivation.

4. Devising ways and means of conserving irrigation water.

5. Exploring possibilities of overhead irrigation for sugarcane.

6. Mechanisation of sugarcane cultivation.

7. Collaborative conduct of long-term experiments on important cultural operations.

Mycology

1. Standardisation of the plug method of inoculation for red rot.

2. Assessment of comparative reaction of sugarcane varieties to red rot infection.

3. Studies on the nature of red rot resistance in sugarcane.

4. Comparative behaviour of varieties in relation to the life cycle of cane to red rot infection.

5. Studies on the laboratory technique of nodal inoculation with red rot.

6. Studies on the wilt of sugarcane in relation to red rot.

7. Assessment of comparative reaction of sugarcane varieties to smut infection.

8. Studies on the physiology of Ustilago scitaminea.

9. Studies on the mode of infection and the development of an inoculation technique with U. scitaminea.

10. Studies on plant parasitic nematodes.

11. Training of research workers in the techniques of plant nematology.

Entomology

1. Studies on the toxicity and persistence of different insecticides in relation to major sugarcane pests.

2. Studies on some promising parasites of sugarcane pests.

3. Study of methods for assessing pest incidence and population.

4. Classification and maintenance of sugarcane insect fauna.

5. Studies on the biology and control of stalk borer, Chilotraea auricilia Ddgn.

6. Study of behaviour of new Co. varieties towards pest incidence.

7. Preparation of critical reviews of entomological work in and outside India and of survey maps relating to the distribution and the intensity of attack of different cane pests in India.

MAIN REPORT

AGRONOMY : SUGARCANE

(R.R. Panje: Agronomist-in-charge)

1. Studies in germination

1) Gradients and interactions in the germination of buds.- The gradients of viability of the successive buds on a cane stalk as affected by the stalk being sub-divided into 3-budded setts were studied. For this healthy cane stalks not damaged by borers were harvested and cut into 3-budded setts; these setts, duly labelled, were planted in the field at random. The experiment was conducted twice, once in autumn 1959 and once in spring 1960. In the former, thirty-nine 12-bud canes, sixty-four 15-bud canes and fifty-six 18-bud canes were used and the setts with clumps were dug up 123 days after planting. In the latter, sixty-seven 12-bud canes, fifty-one 15-bud canes and nineteen 18-bud canes were used and the setts with clumps were dug up 89 days after planting. The data of germination, tillering, clump weight, etc. of each bud on each sett were then recorded and re-assembled for each cane.

As expected, the germination as a whole was better in the autumn-planted cane than in the spring-planted. The principal differences in germination capacity between these however were mostly in the upper portion of the cane; the lower portions of the two were more or less similar. Although viability is high in the upper portion of the cane and does fall off in the lower portion, good viability was found to extend to more than half the length of the cane from top downwards.

Table 1

Germination of the individual buds of a 3-budded sett

Serial order of setts in cane from top downwards	Autumn-planted				Spring-planted			
	Buds of the 3-budded sett							
	Top-end	Middle	Bottom-end	Whole sett	Top-end	Middle	Bottom-end	Whole sett
Top-most	44.9	70.1	50.4	55.1	53.7	69.1	43.8	55.5
2nd	80.3	85.5	43.2	69.7	62.3	75.9	36.4	58.2
3rd	56.0	84.6	48.7	63.1	63.0	72.8	39.5	58.4
4th	62.4	77.8	38.1	59.4	62.8	68.1	40.4	57.1
5th	50.0	71.9	34.4	52.1	55.0	80.0	30.0	55.0
Lowest*	47.9	72.6	33.8	51.4	44.4	71.6	27.2	47.7
Mean	56.9	77.1	41.4	58.5	56.8	72.9	36.2	55.3

* The "Lowest sett" is the 4th sett in 4-sett canes, 5th in 5-sett canes and 6th in 6-sett canes.

The first one or two buds of the top-most sett gave low germination relatively to those of the next lower sett; this is possibly due to these buds being in many cases relatively immature and also because the relevant internodes are more liable to desiccation than those lower down. The lowest sett gave the poorest germination in all groupsof canes, viz. the 4-sett, the 5-sett and the 6-sett canes, and was more or less equally poor in all of them.

The original gradients of viability known to exist in cane stalks are generally maintained only in the middle buds. The top-end bud of the individual sett exhibits the largest variation down the cane, the bottom-end bud of the sett varies less, and the middle bud the least. It appears that the original gradients resolve themselves largely into interactions between individual buds of the setts, and these latter are primarily conditioned by moisture losses from the cut ends which markedly affect the two end-buds of the sett. Presumably apical dominance thereafter plays its role as already reported earlier (Ann. Rep. IISR 1959-60, p.31). (R.R. Panje, P.S. Gill and Bakhtawar Singh).

ii) Influence of length and thickness of setts on their germination capacity.- The material raised in the previous experiment consisting of 654 setts planted in autumn and 770 setts planted in spring was utilised in finding out the relationship if any between the germination capacity and the size of the sett. It was found that, taken overall, neither the length nor the thickness of the sett are correlated with the germination capacity of the sett as a whole.

Since the germination of the two end-buds of the 3-budded sett appeared to be largely controlled by the loss of moisture from the cut ends, a further probe in respect of this relationship was made by taking only the germination of the middle bud and its association with i) the total length of the two complete internodes, and ii) the thickness of the sett. In these cases too, the association was absent. This shows that in the matter of germination, a long sett is as good as a short sett and a thick sett is not superior to a thin one (R.R. Panje, P.S. Gill and Bakhtawar Singh).

iii) Effects of keeping seed-cane before planting.- In earlier findings (Ann. Rep., IISR 1960-61, p.21), it was observed that keeping setts in shade before planting had a beneficial effect on germination provided the setts were thereafter soaked in water. This result was based on experiments conducted in March-April when sett-moisture is barely satisfactory, relative humidities are low and atmospheric temperatures high. In order to see whether a similar improvement in germination could be obtained in November, but without soaking in water in view of the lesser loss of moisture from setts, an experiment with three treatments, viz. i) whole cane kept in shade for 2 days before sett-cutting and planting, ii) setts kept in shade for 2 days before planting, and iii) fresh setts (control) was laid out.

Table 2

Effect of keeping seed-cane before planting

Seed-cane	Kept in shade for	Germination per cent, days after planting	
		82	123
Wholecane	2 days	20.4	39.1
Setts	2 days	18.9	35.1
Setts (Control)	0 day	28.0	42.9
SE .		± 2.5	± 2.5

5 randomised blocks; 30 3-budded setts per plot; Co.1158; planted 23rd November, 1961.

The results (table 2) show that setts kept for 2 days before planting gave poorer germination than fresh setts (control), but the reduction was not statistically significant. The adverse effect was less with whole cane. Apparently, with comparatively immature cane and less severe desiccating conditions, the effect of dryage is presumably less than in March-April, but the germination does not seem to improve by keeping the setts.

In order to assess the dryage effect, the material was weighed before and after the treatment. The loss of weight in whole cane as a result of 2 days' keeping was 3.6 per cent, as against 7.9 in setts kept for the same period. (R.R. Panje, P.S. Gill and M.P. Motiwale).

iv) On the optimum period of keeping setts before planting.- In April 1960, an experiment was conducted which showed that if setts cut from fresh cane are kept for 48 hours in a moisture-proof condition in a polyethylene bag, the germination is greatly improved over that of fresh cane directly planted. (Ann. Rep. IISR 1960-61, p.23). An experiment was conducted this year to find out whether this effect is observed at other periods of the year also when atmospheric conditions and the condition of the sett material are different, and whether a longer period of retention of setts in a moisture-proof condition would improve the effect. In this experiment, setts cut from fresh cane were kept in moisture-proof polyethylene bags for 10, 8, 6, 4 and 2 days, and the material so treated was planted simultaneously against a fresh sett control. Two kinds of bags were used, i) transparent, and ii) black polyethylene. The experiment was conducted every month from December 1961 to March 1962.

Germinations were counted every 7th day. Due to wide changes in atmospheric temperatures in the successive months, the speed of germination varied greatly and due allowance had to be made for adjusting the dates of the counts for purposes of comparisons. Thus the first count in each experiment was made when the germination in the experimental plots was approximately 15 per cent and the last count, about 40 per cent.

Table 3

Effect of keeping of setts in moisture-proof transparent and black polyethylene bags on germination

Setts kept in	for days	Setts planted on 12th December		20th January		15th February		17th March	
		Per cent germination, days after planting							
		63	98	45	59	26	47	20	31
1	2	3	4	5	6	7	8	9	10
Transparent polyethylene bag	10	15.1	46.8	16.8	40.1	17.5	44.6	18.8	31.5
	8	16.2	47.7	18.3	40.1	19.1	50.1	11.6	34.6
	6	11.4	46.6	17.2	39.8	33.5	54.4	22.0	39.2
	4	11.6	48.1	27.8	44.6	21.0	48.3	17.7	38.5
	2	18.7	46.6	28.1	45.5	30.5	49.8	11.3	38.8
Mean		14.6	47.2	21.6	42.1	24.3	49.4	16.3	36.5

1	2	3	4	5	6	7	8	9	10
lack	10	15.5	46.8	25.9	43.8	22.5	46.8	14.8	39.2
oly-	8	13.5	48.5	25.9	44.2	25.1	50.0	21.4	39.8
thy-	6	16.1	47.5	21.0	42.2	25.7	47.9	19.8	46.8
ene bag	4	17.5	49.2	30.7	45.3	26.6	52.2	9.6	34.5
	2	8.8	42.9	29.9	45.3	29.4	49.4	12.9	35.0
ean	-	14.3	47.0	26.7	44.2	25.9	49.3	15.7	39.1
ontrol (fresh setts)	0	9.0	41.2	22.2	38.5	32.0	53.5	11.3	31.8
SD at 5 er cent level		5.25	Not sig.	5.0	Not sig.	8.9	Not sig.	7.5	Not sig.

randomised blocks; 30 3-budded setts per plot; Co.975.

Keeping the setts in moisture-proof bags expedited germinations in all cases except one, and the improvement though small was statistically significant. The differences were maintained during a good part of the germination period, but in the last count they were not significant. In the February-planted experiment however, unaccountably, the germination advantage was with the control.

In respect of the most beneficial duration of storage also, there were significant differences between the treatments. In the December, January and February experiments, the best germinations were mostly obtained with shorter periods of storage, but in March, the better results were with a longer storage duration. However, the results showed considerable variation and some inconsistencies, probably caused by the heterogeneity of storage conditions within the bag. There were no differences due to type of bag used. (R.R. Panje, P.S. Gill and M.P. Motiwale).

v) Effects of moisture depletion and moisture conservation in setts.- A reference is available in literature that in the former plantations in Java, in order to improve germination of setts from the top portions of stalks, setts were allowed to lose a part of their moisture by drying. To test this observation under conditions in north India, an experiment was conducted in November 1961 in which the top-halves of cane stalks which were comparatively immature at that time were subjected to loss of moisture to various extents as follows. The top-halves were cut from freshly harvested canes and divided into two lots: one was topped as usual immediately, while in the other the green leaf-crown was left intact. After sealing the cut ends of the material, each of these lots was divided into two sub-lots; and one lot was kept in a transparent polyethylene bag and the other left without any cover. All the four sub-lots were kept in a well-lighted room for 3 days. The material was weighed before and after the treatment. It was then taken out, cut into setts and planted immediately.

As expected, the loss of weight of top-halves having leaf-crowns was very high, being more than three times as much as that of top-halves kept without leaf-crown (table 4). The weight-loss was much less in material kept in the polyethylene bag, but the differences due to the presence of the leaf-crown were of a similar proportion inter se.

Table 4

Effect of moisture depletion on germination

Top-halves of cane kept for 3 days in a room	Per cent loss in weight	Per cent germination, days after planting				
		81	92	99	106	113
1. Open and with leaf-crown	11.0	14.3	24.4	35.1	38.7	39.3
2. Open, but without leaf-crown	3.1	17.8	23.1	29.0	34.9	36.1
3. In polyethylene bag and with leaf-crown	1.3	21.3	24.7	33.3	35.0	39.1
4. In polyethylene bag but without leaf-crown	0.3	21.1	25.7	31.4	34.9	37.7
5. Control (fresh top setts)	-	20.0	26.7	31.7	36.1	37.2
SE		± 2.0				± 2.3

4 randomised blocks; 45 buds per plot; Co.1158; planted 26th November, 1961.

As regards germination, at the start, the treatment in which moisture of seed material was depleted by keeping the material in the open and with leaf-crown gave about 6 percentage units less germination than fresh cane, but this difference disappeared in later countings (table 4). The removal of leaf-crown mitigated this loss. Where the material was enclosed in a polyethylene bag, the speed of germination was not reduced, and the presence of the leaf-crown made no difference. It thus appears that the velocity of germination is affected by the moisture loss.

The experiment was repeated in the same month with treatments 1, 2 and 5, but the tops were left for 1 day instead of 3 days before planting. The results confirmed the above findings. On the 77th day after planting, the germination of the seed cane kept without its leaf-crown was 6 percentage units lower than the control and that kept with its leaf-crown was 11 units lower. These differences again were largely made up by the time the germination reached about 35 per cent (table 5).

Table 5

Effect of moisture depletion on germination

Top-halves of cane kept for 1 day in a room	Per cent germination, days after planting	
	77	109
With leaf-crown	9.1	34.0
Without leaf-crown	14.4	34.9
Control (fresh setts)	20.4	36.7
LSD at 5 per cent level	6.9	Not sig.

5 randomised blocks; 90 buds per plot; Co.1158; planted 30th November, 1961.

It would appear that loss of moisture in all cases leads to a tardier germination, but that with progress of time possibly due to rooting and the absorption of water, shoots emerged from those buds also which had received a set-back due to dryage. Also, keeping setts in moisture-proof cover does not bring about an improvement in germination when seedcane is comparatively immature and/or conditions of the soil or atmospheric humidity are satisfactory (R.R. Panje, P.S. Gill and Bakhtawar Singh).

iv) Effect of removal of green blades of standing canes before harvest.- Green leaf blades of 50 stalks were removed 30, 18 and 6 hours before the harvest of cane for seed purposes in three respective treatments. The defoliated stalks in all the treatments were harvested at the same time, cut into setts and planted against a normally harvested and topped control.

Table 6

Effect of removal of green blades of standing canes on germination

Green blades removed, hours before harvest	Per cent germination, days after planting				
	78	87	94	101	108
30	6.0	13.8	26.0	31.8	33.3
18	4.0	14.2	27.1	34.7	37.1
6	9.3	18.2	26.9	31.6	34.7
0 (Control)	17.1	27.1	34.2	38.0	40.0
LSD at 5 per cent level	4.6				4.6

5 randomised blocks; 30 3-budded setts per plot; Co.1158; planted 1st December, 1961.

Removal of green leaves before harvest adversely affected the start of the germination of the seedcane, the effect being more or less directly related to the duration of the defoliated condition before harvest. On the 78th day after planting, the difference between the defoliated stalks and the control was significant at 0.01 per cent level. This again was largely made up by the 108th day, when the differences were significant at only 5 per cent level. The differences between the defoliation treatments inter se were non-significant (R.R. Panje, P.S. Gill and Bakhtawar Singh).

vii) Estimate of loss of moisture through various surfaces of a 3-budded sett.- Earlier studies (Ann. Rep. IISR, 1960-61, i, iv to vi, pp.21-24) had indicated that the most important factor which influenced the germination of buds in north India was loss of moisture from setts during planting. In a 3-budded sett, dryage affected the germination of the end-buds more than that of the middle bud. An assessment of the losses of moisture through the various surfaces of the 3-budded sett was therefore made. Setts were cut as usual and the different surfaces of the setts were coated with beeswax so as to allow evaporation from certain restricted surfaces only. Two kinds of setts were used: those cut with a gandasa (chopper) and those with a knife. The setts were allowed to lose moisture for 3 days in a room, and the loss of moisture was roughly estimated by weighing the setts before and after the 3-day period.

Table 7

Loss in weight through various surfaces of a 3-budded sett

Surfaces exposed	Per cent loss in weight after 3 days in setts cut by			
	Gandasa		Knife	
	Gross loss	Net loss	Gross loss	Net loss
MCE: All parts exposed	6.4	5.9	5.4	4.8
MC: Only rind surface of all internodes exposed	3.1	2.4	2.2	1.6
CE: Only rind surface and cut ends of cut-end internodes exposed	4.8	4.1	4.5	3.9
M: Only rind surface of full internodes exposed	4.3	3.6	4.6	4.0
E: Only cut ends exposed	3.4	2.7	4.1	3.5
No surface exposed	0.7	0.0	0.5	0.0

4 replications; one 3-budded sett per treatment; Co.1158; experiment started 14th December 1960.

M: Rind surface of middle internodes exposed, C: Rind surface of cut-end internodes exposed, E: Cut surfaces of end internodes exposed.

It is observed that even when a sett is completely covered with wax, there is a loss of 0.7 per cent in weight in 3 days; this is obviously due to causes other than loss of moisture. If allowance is made for this, the rate of loss in a sett comes to be about 1.5 to 2 per cent per day.

It is also observed that the loss in weight takes place even when the cut ends are sealed. A loss in weight of more or less equal magnitude takes place when the rind surface alone is exposed. The relative proportion between the two losses would obviously depend upon the length and girth of the sett, and the lengths of the respective internodes exposed to evaporation (R.R. Panje and P.S. Gill).

viii) On loss in weight of setts planted in soil.- Presumably where the moisture status of the soil is low, loss of moisture from setts would continue even after the setts are planted, and the effect of this cane be equally deleterious to germination. To assess these losses, a series of experiments was conducted in November 1961 and March 1962. In the November-experiment, 60 freshly-cut setts of variety Co.1158 were taken, their buds scooped away and the depression so left sealed off with beeswax. The setts were individually weighed and immediately planted out in the normal manner. Of these, 12 at a time were dug up at random at intervals of 3-4 days and weighed after removal of adhering soil. Another lot of 12 setts were similarly weighed, but were kept in the room as control, being weighed each time a batch of 12 of the planted setts was weighed. The loss in weight was worked out as per cent loss on fresh weight of the individual setts in all cases.

Table 8

Loss in weight of setts planted in soil and kept in room

Days after planting	Per cent soil moisture	Per cent loss in weight of setts	
		Planted in soil	Kept in room
3	15.3	0.7	5.7
7	12.5	1.4	11.0
10	11.8	0.5*	14.8

* Setts started rooting

The results (table 8) show that even when the soil had as much as 12 to 15 per cent moisture, planted setts lost about 0.2 per cent of their fresh weight per day during the first 7 days of planting. In the setts kept in the room, the loss in weight was about 8 times as high (table 8).

The experiment was repeated in March when the soil moisture had fallen to about 7-11 per cent. The loss in weight in the soil of planted setts per day under these conditions was on the average slightly higher than in November. In the open room the loss was more or less of the same order as in November.

In the March experiment, setts soaked in water were also included. In the open, soaked setts lost comparatively more weight than the unsoaked ones (table 9). In the soil, the loss in weight is distinctly higher in soaked setts than in unsoaked.

Because of the variation between different batches of planted setts weighed each time, data are not as consistent as those of setts in the open.

Table 9

Loss in weight of setts soaked in water, kept unsoaked, planted in soil and kept in room

Days after planting	Per cent soil moisture	Per cent loss in weight of setts			
		Planted in soil		Kept in room	
		Setts soaked in water	Unsoaked setts	Setts soaked in water	Unsoaked setts
0	10.5	0	0	0	0
3	11.3	1.1	1.1	6.1	5.3
6	6.8	2.2	1.2	10.1	9.0
9	8.3	5.0	2.0	14.0	13.0
12	7.0	6.1	3.8	19.6	17.1
18	7.0	8.7	8.4	26.6	23.9
Mean per day		0.48	0.34	1.60	1.42

It may be mentioned here that loss in weight is the nett result of many factors, which vary as between open air and in soil. The above data have been gathered only to have a broad idea of nett effect on the presumption that loss of water by evaporation or otherwise accounts for the principal part of the loss in weight of setts. This assessment is good only for guidance in certain practical purposes of seed handling (R.R. Panje, P.S. Gill and M.P. Motiwale).

ix) Effect of certain moisture-proofing materials on loss of weight of setts.- With a view to seeing the effectiveness of certain moisture-proofing materials in preventing loss of moisture from setts, an experiment with four treatments viz. i) setts dipped in 12 per cent waxol, ii) setts coated with 20 per cent shellac, iii) setts soaked in water for 4 hours and iv) untreated setts was conducted, the setts being placed a) in the soil and b) in the open in a room. Ten 3-budded setts were used per treatment. The loss in weight of setts was estimated at 3-day intervals.

Table 10

Loss in weight of setts treated with moisture-proof materials under soil and room conditions

Days after planting	Per cent soil moisture	Per cent loss in weight of setts: Planted in soil after: Dipped in 12 per cent waxol	Coated with shellac	Soaked in water	Untreated	Kept in room after: Dipped in 12 per cent waxol	Coated with shellac	Soaked in water	Untreated
0	10.8	-	-	-	-	-	-	-	-
3	6.0	0.7	0.6	2.8	1.4	7.3	6.1	9.3	6.5
6	5.3	1.8	1.6	5.4	2.4	12.0	10.5	16.8	12.1
9	6.0	5.1	1.7	5.1	5.7	17.8	16.5	23.2	17.3
12	5.5	5.3	1.2	12.5	7.6	22.2	20.7	28.4	21.7
15	5.0	6.7	2.8	10.4	9.2	26.4	25.2	33.9	26.4

Of the two materials used, shellac-coating appears to have given a better protection from weight loss in planted setts than wax-dipping (table 10). In the open, neither of these coatings seems to have been effective in checking moisture loss. Last year, both 6 and 12 per cent emulsion of waxol markedly helped to cut down weight loss of setts in the open (Ann. Rep. IISR 1960-61, I, vi, p.24). The reason for its non-effectiveness this year is not clear. As observed in experiments ix and viii above, the loss in weight was more in setts soaked in water than unsoaked ones, and the weight loss under planted conditions was about one-third of that in setts kept in the open (R.R.Panje, P.S. Gill and M.P. Motiwale).

x) Effect of dipping setts in waxol on the germination of buds.- To see whether waxol dipping also brings about an improvement in germination of setts, an experiment with 3 treatments (table 11) was planted.

Table 11

Effect of dipping setts in waxol on germination

Treatments	Per cent germination, days after planting: 19	36
Setts soaked in water for 4 hours and dipped in 12 per cent waxol	47.5	69.0
Setts soaked in water (Control)	39.0	66.4
Setts untreated (Control)	21.3	52.9
LSD at 5 per cent level	7.2	7.9

6 randomised blocks; 40 3-budded setts per plot; Co.975; planted 5th March 1962.

The results (table 11) show that 19 days after planting, setts soaked in water and dipped in waxol gave about 23 per cent more germinated shoots in the plot than the soaked control. Soaking in water by itself nearly doubled the germination. The differences were statistically significant. By 36th day, the differences between the two soaked cane treatments narrowed down, but they were both still significantly superior to the unsoaked control (R.R. Panje, P.S. Gill and M.P. Motiwale).

xi) Effect of shellac-coating of setts on the germination of buds.- Since in experiment ix it had been found that loss in weight of setts was much better prevented by 20 per cent shellac than by waxol, an experiment was conducted to compare the relative merits of these two coatings on the germination of 3-budded setts.

Table 12

Effect of shellac-coating and waxol-dipping on the germination of buds

Treatment	Per cent germination, days after planting	
	18	24
Setts coated with 20 per cent shellac	10.5	45.0
Setts dipped in 12 per cent waxol	5.5	30.3
Control (untreated)	2.3	22.2

5 randomised blocks; 40 3-budded setts per plot; Co.1158; planted 30th March 1962.

The results (table 12) show that shellac-coating markedly expedited and improved the germination of buds. On the 18th day after planting, the number of shoots in this treatment was nearly 5 times as high as the control, and twice as high on the 24th day. There were differences between the shellac-coated and waxol-dipped setts too. But all differences were non-significant, probably because of the varying and uneven moisture conditions which are set up in the soil in the late season (R.R. Panje, P.S. Gill and M.P. Motiwale).

xii) Effects of application of Aretan in different ways on the germination of buds.- In an earlier experiment (Ann. Rep. IISR, 1960-61 p.24), it was observed that soaking of setts in Agallol, an organo-mercurial compound, expedited germination better than dipping. Soaking in Agallol (or Aretan) however is an expensive treatment. Therefore to see as to what extent the benefit due to soaking could be obtained through keeping the setts under moisture-proof cover before planting and subsequently dipping them in Aretan solution, an experiment was conducted with 12 treatments (vide table 13).

Table 13

Germination of stale and fresh seed-cane with and without soaking/dipping in Aretan

Treatment of setts before planting			Per cent germination, days after planting	
Keeping for 2 days	Soaking for 3 hrs.	Dipping	21	28
1	2	3	4	5
1. In shade	-	-	5.3	22.4
2. In shade without cover	in water	-	33.6	44.4
3. In shade without cover	in 0.2 per cent Aretan solution	-	41.0	54.0

1	2	3	4	5
4. In shade without cover	in 0.5 per cent Aretan solution	-	33.3	48.8
5. In shade under polyethylene cover	-	in 0.2 per cent Aretan solution	45.0	54.3
6. In shade under polyethylene cover	-	in 0.5 per cent Aretan solution	45.8	54.2
7. Control*	in water	-	32.6	45.7
8. "	in 0.2 % Aretan solution	-	45.3	57.4
9. "	in 0.5 % Aretan solution	-	35.1	47.4
10. "	-	in 0.2 per cent Aretan solution	41.1	51.4
11. "	-	in 0.5 per cent Aretan solution	32.2	44.3
12. "	-		18.6	34.3

* Fresh cane planted directly without keeping in shade; 4 randomised blocks; sixty 3-budded setts per plot; Co.S.510; planted 1st April 1961.

As against 18.6 per cent germination in fresh setts and 5.3 per cent in setts kept in shade for 2 days after harvest, soaking for 3 hours in water gave 32.6 per cent and that in 0.2 per cent Aretan gave 45.3 per cent on the 21st day. Seed kept in shade for 2 days germinated to 33.6 per cent when soaked in water, and 41.0 per cent when soaked in 0.2 per cent Aretan. Polyethylene film storage followed dipping in Aretan solution increased the germination to about 45.0 per cent. The differences between the latter treatments (no.5 & 6 in table 13) and fresh cane (no.12) were significant at 0.1 per cent level (R.R. Panje, P.S. Gill and J.P. Misra).

xiii) Effect of BSM-11 on the germination of buds.- For testing the effect of BSM-11 a formulation offered by Messrs. Buckman Laboratories, Inc. of Tenn. U.S.A. for use as a protective agent for sugarcane cuttings, setts were dipped in 0.25, 0.50 and 1.00 per cent solutions of the substance before planting and compared against setts dipped in 0.5 per cent Aretan and fresh setts (control). Dipping in BSM-11 solutions improved the germination, particularly 1 per cent solution, but 0.5 per cent Aretan was still better; the germination was strikingly higher at the start with Aretan dipping and the advantage was maintained upto 4 weeks after planting. The present results are only indicative and need confirmation. (R.R. Panje, P.S. Gill and M.P. Motiwale).

xiv) Effects of spray irrigation of cane crop on the viability of seed cane.- To find out whether sprinkler irrigation during the dry winter season would improve the germinating capacity of a seed crop a crop of cane was given spray irrigation daily for 21 days, 4 hours per

day. The results (table 14) show that the viability or speed of germination was not improved (R.R. Panje, P.S. Gill and Bakhtawar Singh).

Table 14

Effect of spray irrigation on standing cane on its germination

Cane crop given	Per cent germination, days after planting	
	23	37
Ground irrigation	27.6	44.7
Spray irrigation	29.2	44.9
S.E.	± 1.2	± .0

10 randomised blocks; 30 3-budded setts per plot; Co.453; planted 17th March 1962.

xv) Effect of thickness and compaction of soil cover on the emergence of germination shoots.- Following on certain small scale experiments conducted during the past two years by the Soil Science Section (Ann. Rep. IISR, 1959-60, p.48 and 1960-61, p.54) an experiment on the effect of thickness and compaction of soil cover over planted setts was carried out in April 1961, wherein trench-planted setts with 4 cm loose soil cover, 4 cm compact soil cover and 10 cm loose soil cover were compared against flat-planted setts with 10 cm loose soil cover.

Table 15

Effect of thickness of soil cover on germination

Treatments	Per cent germination, days after planting	
	14	21
Trench planting with 4 cm compact soil cover	32.6	58.6
Trench planting with 4 cm loose soil cover	16.0	29.6
Trench planting with 10 cm loose soil cover	24.0	57.3
Flat planting 10 cm partially compact soil cover	20.0	30.7
LSD at 5 per cent level	9.1	8.9

3 randomised blocks; 40 3-budded setts per plot; Co.S.510; planted 7th April 1961.

On the 14th day, germination under the 4 cm compact soil cover in trenches was twice as good as the 4 cm loose cover and 36 per cent better than the 10 cm. loose soil cover (table 15). Trench planting with 4 cm loose cover and flat planting with partially compact soil cover gave more or less equal germinations and these were significantly poorer than the trench planting with 4 cm compact and 10 cm loose soil cover. The differences became very distinct after 21 days of planting. The result indicates that a thin compact soil cover is as good as a thick loose one (P.S. Gill and Rajendra Singh).

2. Studies in tillering

i) Gradients in tillering.- The influence of position of

bud both on the cane stalk and on the 3-budded sett on its tillering were studied in continuation of the germination gradient experiment reported earlier (q.v.p.14 .). In this study the fresh weight of the clump formed out of each bud of each sett was recorded. The material was uprooted for the studies 123 days after the autumn-planting and 89 days after the spring-planting.

Table 16

Dry weight in g. of clumps formed out of different buds of 3-budded sett

Serial order of setts in cane from top downwards	Autumn-planted				Spring-planted			
	Buds of the 3-budded sett							
	Top-end	Middle	Bottom-end	Mean for the sett	Top-end	Middle	Bottom-end	Mean for the sett
Top-most	16.7	17.4	9.5	14.5	75.6	74.1	52.4	67.4
2nd	15.5	15.8	6.0	12.4	77.3	98.5	63.6	79.8
3rd	12.9	16.5	9.7	13.0	68.8	109.5	61.0	79.8
4th	11.5	18.0	6.2	11.9	78.3	103.9	56.2	79.5
5th	11.0	16.3	6.1	11.1	37.7	113.7	46.3	65.9
Lowest*	11.2	12.7	13.4	12.4	90.5	85.9	66.1	80.8
Mean	13.1	16.1	8.5	12.5	71.4	97.6	57.6	75.5

* The "Lowest sett" is the 4th sett in 4-sett canes, 5th in 5-sett canes and 6th in 6-sett canes.

As expected, the proliferating capacity of the spring-planted crop is far higher than that of the autumn-planted one (table 16). This again is accountable to the more favourable conditions for plant development in the post-winter period.

The middle bud produces the highest clump weight followed by the top-end bud; the output of the bottom-end bud is almost always distinctly poorer.

It was observed in earlier studies (Ann. Rep. IISR, 1960-61, p.16) that the germination of any one bud on a sett is influenced by the non-germination of the next one. This negative association appears to influence the subsequent tillering. In the overall therefore, the gradient of the original stalk is no longer noticeable in the trend of weights of the clumps. (R.R. Panje, P.S. Gill and Bakhtawar Singh).

ii) Relationship between dimensions of the internodes and the weight of the clump.- The above data was further utilised to study the relationships between the length and thickness of the internodes and the weight of the clump at tillering time. From the correlations (table 17) it appears that neither the length nor the thickness of the internodes influence the clump weight (R.R. Panje, P.S. Gill and Bakhtawar Singh).

Table 17

Co-efficients of correlation between the dimensions of the sett and the weight of the clump at tillering time

Correlation between the weight of clump from the middle bud and the	Autumn-planted	Spring-planted
Length of 1st full internode	+ 0.062	+ 0.137
Length of 2nd full internode	+ 0.019	+ 0.165
Thickness of 1st full internode	+ 0.100	+ 0.113

iii) Plant density in relation to seed-rate in autumn-planted sugarcane.- Earlier investigations (Ann. Rep. IISR, 1955-56 and 1956-57) had shown that the autumn-planted crop under north Indian conditions, due to its several months' earlier start has a long period of tillering, and with the usual seed-rate, there is excessive shoot formation and very high shoot mortality. To study the effect of reduction in seed-rate, row density and other characteristics of the autumn-planted crop, an experiment with three levels of seed-rate, viz. 20,000, 27,000 and 34,000 (normal) 3-budded setts per hectare was laid out. The spacing between rows was 92 cm in all cases.

Table 18

Effect of seed-rates on plant density, millable canes yield and juice-quality in autumn-planted sugarcane

mber f setts lant- l per ctare n thou sands	Germi- nation per cent	Number of shoots in thousands per hectare on						Milla- ble ca- nes in thou- sands per hectare	Cane yield in metric tons per hectare	Juice-quality in December	
		15th March	20th April	15th May	14th June	17th July	16th August			Pol per cent	Purity
)	34.2	20.1	70.0	102.9	99.6	81.1	76.5	50.2	52.59	13.24	81.3
'	33.9	27.8	86.8	116.8	108.9	84.8	83.1	52.2	57.06	13.58	82.5
	32.4	34.7	122.6	146.8	129.1	94.2	85.0	55.1	59.42	13.90	82.8
rcentage vel at ich sig- ficant		0.1	0.1	1.0	0.1	5.0	Not sig.	Not sig.	Not sig.	Not sig.	Not sig.
D at 5 per cent vel		3.2	10.0	19.0	8.0	8.6					

randomised blocks; net plot size 92 m^2; Co.951; planted 30th November 1960.

The experiment was planted on 30th November 1960. Germination however was completed only by 15th March, 1961. The germination percentages were more or less similar in the three treatments; accordingly, the starting shoot populations showed differences practically corresponding to the seed rates (table 18).

The peak shoot density, attained in the middle of May was in direct relation to the seed rates used, but was not proportionate, the number of shoots per plant being less in the higher seed rates. The differences in shoot population per hectare remained significant upto July 1961; after this as a result of higher mortalities in the higher seed-rate treatments, the populations became more nearly equal. Residual differences remained in the three treatments at harvest both in respect of the number of millable stalks and the yield of cane per hectare, but these differences were non-significant.

These results suggest that with autumn-planting, there is a clear scope for reduction of seed rate by upto 40 per cent. Further reductions (with corresponding economics in labour costs) may be possible in October- and September-planted cane crops as these have a greater shoot producing capacity than the November-planted (P.S. Gill and Masood Alam).

iv) On the absolute spatial requirements of cane clumps.- Spacing experiments are usually carried out only on the factor of inter-row distance (e.g. 3 ft. 2 ft. etc.) and less commonly on the density of setts in

the row (e.g. end-to-end, overlapping, double-series, etc.). The latter category of experiments originate from the low expectation of germination, and the primary intention of these experiments has been to ascertain the minimum number of setts required to ensure a full row of shoots. In none of these experiments has an attempt been made to ascertain the absolute space required by an individual cane plant for its full function under a uniform density of distribution.

For this assessment, an experiment with three check-pattern spacings 45.7, 61.0 and 76.1 cm (1.5, 2 and 2.5 ft.) was conducted. Two varieties were used, i) Co.951 which has medium-thick stalks, wide leaves and a spreading crown, and is late in ripening and ii) Co.S.514 which has medium-thin stalks, narrow sheat leaves and a compact crown, and is early in ripening. In order to ensure a full stand of clumps one-budded setts cut at nodes were employed, each being planted at an intersection of the check-pattern.

The results brought out a series of facts to light (table 19). With increase in ground area per clump, the individual clumps tillered more, and later more tillers out of a clump survived and formed canes. The number of millable canes thus left in the wider spacings, more than compensated for the fewer clumps, so that at harvest there were more canes per hectare with treatments with reduced seed rates. Since the individual stalks were also thicker and heavier in the wider spacings, the yield per hectare was distinctly more.

The trend of response to the spacing factor was similar in the two varieties, but there were differences of degree between them in the various aspects of yield increase. In Co.951, the response in tillering was less and its shoot survival rate was also lower, and thus it maintained relatively smaller stalk populations at harvest than Co.S.514. On the other hand, as a variety it was characterised by thicker and heavier stalks and these characteristics responded more increased spacing. Thus although the wider spacing increased the yield per hectare in both varieties, Co.951 availed of the greater area per clump more by producing thicker and heavier canes, while Co.S.514 exploited the increased space more by producing larger numbers of tillers, shoots and higher survivals of stalks at harvest.

In the both varieties, the 76.1 cm (2.5 ft.) square spacing gave a significantly higher yield than 45.7 cm (1.5 ft.) square spacing. The other differences in yield were non-significant. On the whole, judging by yields per hectare, Co.951 appeared to have responded better (26.4 per cent) to wider spacing than Co.S.514 (15.1 per cent). Unfortunately, the experiment was partially vitiated by severe lodging in Co.951 as a result of which the yield in this variety was much below its normal. For the same reason the juice-quality figures were also aberrant.

Table 19

Effect of absolute clump area on various characteristics of cane

Particulars	Co.951			Co.S.514			LSD at 5 per cent
	Linear distance between adjacent clumps and area per clump						
	45.7 cm 0.21 sq meters	61.0 cm 0.37 sq meters	76.1 cm 0.58 sq meters	45.7 cm 0.21 sq meters	61.0 cm 0.37 sq meters	76.1 cm 0.58 sq meters	
1	2	3	4	5	6	7	8
Number of clumps in thousands per ha	47.7	26.9	17.3	47.7	26.9	17.3	
Number of shoots per clump	5.7	7.3	9.7	5.9	8.8	11.0	

1	2	3	4	5	6	7	8
Area per shoot in cm	366	510	597	354	423	526	
Number of shoots in thousands per ha	272	196	167	281	237	190	
Per cent survival of shoots	13.9	20.8	25.1	25.1	35.8	47.0	
Number of canes in thousands per ha	37.8	40.8	41.9	70.6	84.7	89.3	
Number of canes per clump	0.79	1.52	2.42	1.48	3.15	5.16	
Area per cane in cm^2	2,644	2,448	2,393	1,411	1,181	1,122	
Weight per cane in kg	0.69	0.79	0.87	0.50	0.45	0.49	
Thickness of cane in cm	2.13	2.23	2.35	1.83	1.73	1.75	
Yield in metric ton per ha	25.69	29.77	32.48	41.35	44.19	47.61	5.79
Pol per cent juice	13.88	13.37	14.59	17.03	15.37	15.59	
Purity	82.6	80.3	83.0	87.6	85.5	84.7	

4 randomised blocks; net plot size 167.4 m^2; planted 24th November, 1960.

The experiment has given an insight into many aspects of crop formation and varietal behaviour. One paradoxical and therefore important observation is that whereas the area available per shoot was less in the closer spacing, each millable cane in wider spacings was able to do with less space for itself than it could do in closer spacings. This observation may hold the key to a new approach in the management of cane stalk populations, and on this may depend a principle governing the prescription of seed rates. From the point of view of production, the implication of the results is that within limits of the experimental treatments used, increase in spacing has led to an increase in yield per hectare and the optimum limit of spacing does not appear to have been reached even though the area allowed per clump has been more than doubled, i.e. from 2,800 cm^2 (which is what a clump gets in the usual 3 ft. spacing, 15,000 setts per acre and 30 per cent germination) to 5,800 cm^2. As against 1,200 cm^2 which a surviving millable cane gets in the usual spacing, the canes of Co.951 in the widest spacing treatment have grown to retain for themselves 2,400 cm^2 and still yielded higher. This result is partly accounted to November planting and partly to the normal care given to the crop after germination. However, the results require further testing; the experiment is being repeated (R.R. Panje, P.S. Gill and J.P. Misra).

3. Studies on the conservation of moisture for sugarcane crop

i) On the use of soil cover and trash-veins in alkaline soils.

In the course of observations in the field, it was noticed that since cane is fairly tolerant of alkalinity, some of the principal obstacles

to the proper functioning of the cane plant in alkaline soils may be overcome by maintaining the soil at a good level, and that since water supply in such areas is itself usually expensive, the need of the case may be partially at least met by conservation of the limited supply of water. An experiment was therefore laid out with two treatments, viz. i) using black polyethylene film as a soil cover, ii) chopped cane trash as veins, both these for the purpose of keeping the soil moist and preventing wide changes in the condition of the soil, against iii) a normally planted control. Since the alkaline patch available at the Institute farm was small and the reaction of its soil varied from spot to spot, the experiment had to be carried out with a small plot-size and replications increased to the maximum possible. Planting was done in furrows on 10th March 1961 and the polyethylene cover and trash veins were laid on 26th April 1961. Three pre-monsoon irrigations were given to all the plots. The pH of the field in which the experiment was laid out ranged from 8 to 9.8.

The results were as follows. The polyethylene film cover kept from 2.0 to 3.5 percentage units, and the trash veins 0.5 to 3.0 units more moisture in the top soil below them than was present in the control (table 20).

Table 20

Effect of polyethylene cover and trash veins on soil moisture in alkaline soil

Treatment	Moisture per cent at sett level on				pH in replications					
	17th May	1st June	15th June	23rd June	I	II	III	IV	V	VI
Black polyethylene film cover	6.5	11.5	13.5	10.7	8.5	8.5	8.5	9.7	9.4	8.5
Cane trash veins	6.0	10.0	13.0	8.5	8.3	8.2	9.1	9.8	7.7	8.0
Control	4.5	9.0	10.0	8.0	9.4	8.3	9.4	9.7	8.6	8.3

The crop showed a surprising degree of improvement in tiller formation and growth as a result of the polyethylene film cover and trash veins (table 21). Between April and mid-June, the shoot population quadrupled itself to its peak in the polyethylene plots and trebled itself in the trash vein plots, whereas in the control the number increased only to 275 per cent of the original, which, however, was lower to start with. In mid-June, the populations in the three treatments were roughly in the ratio of 9:6:5.

Table 21

Effect of polyethylene cover and trash veins on shoot density in alkaline soil

Treatment	Number of shoots in thousands per hectare on					
	26th April	17th May	1st June	15th June	30th June	23rd July
Black polyethylene film cover	46.3	55.3	122.6	197.3	184.2	150.1
Cane trash veins	46.9	53.2	74.2	129.5	122.3	109.4
Control	40.7	46.3	59.8	110.6	102.3	91.2
Percentage level at which significant	Not sig.	5.0	Not sig.	5.0	1.0	1.0
LSD at 5 per cent level	-	6.1	-	63.0	40.3	27.5

6 randomised blocks; net plot size 16.7 m^2; B.0.17; planted 10th March, 196

At harvest, the stalks in the polyethylene cover and trash vein treatments were about 22 per cent taller than those in the control, but these differences were not significant. The millable stalk populations however showed differences corresponding to those at the commencement of the monsoon and the same were significant at 1 per cent level.

The yields of cane as calculated from the middle row in each plot were 27 and 22 metric tons per hectare higher in the polyethylene cover and trash vein treatments respectively than in the control (table 22), the differences being significant at 1 per cent level. The yield from 3 rows showed a similar trend. The differences in juice-quality were small and non-significant.

Table 22

Effect of polyethylene cover and trash veins on length and number of millable stalks, yield and juice quality of sugarcane in alkaline soil

Treatment	Mean length of cane in cm.	Millable canes in thousand per ha	Cane yield in metric tons per ha	Juice-quality in December	
				Pol per cent	Purity
Black polyethylene cover	188.4	117.5	47.53	15.16	87.0
Cane trash veins	188.4	92.7	42.75	15.18	85.8
Control	154.2	60.1	20.77	15.41	87.6
Percentage level at which significant	Not sig.	1.0	1.0	Not sig.	Not sig.
LSD at 5 per cent level	-	28.7	13.51	-	-

6 randomised blocks; net plot size 16.7 m^2; B.O.17; planted 10th March, 1961.

An analysis of the data in relation to the pH value of the individual plots suggests that, for all the improvement effected in the crop, the influence of the soil reaction persisted in the yields of the polyethylene covered plots and trash vein plots. But whereas in normal soils, trash cover usually increased cane yield by about 3 to 5 metric tons per hectare, in alkaline soils improvement obtained has been as much as 22 to 27 metric tons. Confirmatory experiments, are in progress. The results now obtained hold a promising means for inexpensively improving the productivity of alkaline soils (R.R. Panje, P.S. Gill and Masood Alam).

4. Studies on cultural system and practices for sugarcane

i) The transplantation method of raising sugarcane crop under north Indian conditions.- An experiment was carried out on moisture conservation at this Institute in 1960-61 (Ann. Rep. IISR, 1960-61 p.28) and the various studies on germination led to the expectation that cane can be sprouted and raised in nurseries in north India in spite of the cold weather, for the transplantation of fully germinated setts with shoots at the appropriate time. To test out this possibility, a small unreplicated experiment was conducted in December 1961. Setts of Co.975 were cut and placed in a single layer parallel and close to each other on a nursery bed. They were lightly irrigated, and then covered over with 150 gauge transparent polyethylene film, the edges of the film being tucked into the soil around. The nursery was set up on 14th December 1961.

The buds started bursting within 7 or 8 days. But a few days after setting up the nursery, an unprecedented cold wave of several days' duration prevailed over Lucknow; due to this, the development of the shoots was slowed down, but still none of the shoots was killed. Within a month most of the shoots had grown to the 2-3 leaved stage, and on 18th January 1962, the polyethylene film was removed; after watering the nursery a little, the setts were collected from the nursery with a 'khurpa' for transplantation.

It was found that the germination of buds was over 95 per cent. The shoots measured to the last transverse mark were on the average about 6 cm. high.

After taking the necessary data, the blades on the shoots were clipped off, and the setts bearing the stumps (slip-setts) were transplanted in furrows with a light irrigation to establish them. There was practically no mortality in the transplanted material. The stumps put out blades without any delay and fully formed shoots were established within a week or 10 days.

The subsequent growth of the shoots was very satisfactory and tillering was rapid. At the end of the year under report, the crop was showing a thick stand of foliaceous shoots.

Further work on this technique is being taken up, as it appears to hold some prospect of commercial application. Its main and somewhat unique feature is that it gives a partial control over the factors vitally affecting germination under north Indian conditions; their control may make possible many further improvements in its train. The technique may enable many economies, viz. in seed, labour and water, while at the same time ensuring a gapless stand and providing a longer period of growth to the crop in spite of limitations of climate. (R.R. Panje and P.S. Gill).

Table 23

Germination of buds and length of sprouts in nursery under a polyethylene cover

Setts	No. of buds sprouted or fully of germinated out/20 laid in the nursery			Mean per cent germination		Length of sprouts in cm			
	Top-end bud	Middle bud	Bottom-end bud	on basis of buds used in sett cutting	on basis of buds planted	Top-end bud	Middle bud	Bottom-end bud	Mean for sett size, & sett-cuts
Internodal cut									
1-budded	19	-	-	95.0	95.0	3.7	-	-	3.7
2-budded	19	20		97.5	97.5	2.3	-	1.8	2.0
3-budded	20	20	19	98.3	98.3	4.7	6.6	1.3	4.2
Mean						3.6	6.6	1.4	3.3
Wax-band cut									
1-budded	18	-	-	90.0	90.0	4.3	-	-	4.3
2-budded	19	20	-	97.5	97.5	3.9	-	0.8	2.3
3-budded	20	20	20	100.0	100.0	8.3	6.5	2.2	5.7
Mean						5.3	6.5	1.5	4.1
Nodal cut									
1-budded	19	-	-	47.5	95.0	10.0	-	-	10.0
2-budded	19	19	-	63.3	95.0	12.1	-	9.9	11.0
3-budded	20	20	20	75.0	100.0	15.2	9.6	9.8	11.5
Mean						12.4	9.6	9.9	10.5

ii) Effect of size and place of cutting of setts in polyethylene nursery conditions.- Nine types of setts were used in the experiment on the polyethylene nursery system, 1-, 2-, and 3-budded setts, each cut in three different ways, viz. on internode, waxband and node. The data (table 23) show that sprouting was equally high in all types of setts, including the 1-budded, which usually almost fail to germinate when planted in the normal manner. In the presence of optimum conditions for germination, the effect of sett-type is reflected on the elongation of the shoot, since this is only a prolongation of the germination phenomenon. As between sett-sizes, the 3-budded sett has all through given the longest shoots on the average. As between buds in the 3-budded sett, the middle bud has distinctly better growth than the top-end bud; but this appears to be a function of the extent of internode on either side, for where, as in the nodal-cut 3-budded sett, a complete internode is provided on either side, the top-end bud has given a markedly longer shoot than the middle bud. Further the place of cutting has some influence on the shoot length. There is an indication that other conditions remaining the same, a reduction in internode on either side affects the growth of the shoot.

The effect of providing a complete internode at either end of the sett is quite striking in all types of setts. On the average, the growth rate of shoots in the nodal-cut material is three times as much as that of the normal internodal-cut material. In 3-budded setts, the nodal cut results in the loss of 25 per cent of the buds, but the increased growth, which is 250 per cent, may more than compensate for this loss. Actually for the top-bud in a 2- or 3-budded sett the difference between waxband cut and nodal cut is of a small order, but this seems to make a great deal of difference to the growth of this shoot. This finding opens out important indications and has certain prospect of commercial utility (R.R. Panje and P.S. Gill).

5. Studies on the control of weeds in sugarcane fields

i) On time of application of Dowpon.- Dowpon is reported to be an effective weed-killer. To find out the best time of application of Dowpon, an experiment was conducted with 4 times of application of a dose of 11.2 kg per hectare each time. The treatments were applied at i) pre-emergence, ii) post emergence, iii) peak tillering and iv) end-tillering stages of the cane crop. The results are given in table 24.

Table 24

Effect of application of Dowpon on weed mortality, shoot production, millable canes, yield and juice-quality of sugarcane

Crop stage at application of Dowpon	Per cent mortality of weeds	Tillers per plant on			Millable canes in thousands per hectare	Cane yield in metric tons per hectare	Juice-quality in December	
		23rd June	18th July	18th August			Pol per cent	Purity
Pre-emergence	nil	2.5	2.0	2.2	41.7	14.70	15.23	85.0
Post-emergence	31.3	1.5	0.7	0.8	12.5	3.28	13.79	82.9
Peak tillering	10.8	2.1	1.4	1.4	27.8	9.38	14.93	85.1
End of tillering	3.5	3.8	3.0	3.6	66.7	20.01	14.10	84.1
Control (non-treated)	nil	4.1	3.1	3.0	81.6	33.86	14.86	84.9
LSD at 5 per cent level						6.54		

3 randomised blocks; plot size 77 m^2 ; Co.S.510; planted 20th March 1961.

Mortality of weeds appeared to be maximum when the weed-killer was applied at the post-emergence stage, but even as such it was only about 31 per cent of the weeds. Pre-emergence application and the application made at the two tillering stages were much less effective; and in addition they hurt the cane crop very badly, the result being reduced shoot production, fewer millable canes and lower yield. The injurious effect of Dowpon on cane was progressively less with later applications. Control (non-treated) gave a higher number of millable stalks and produced a significantly higher yield than any of the Dowpon treatments (P.S. Gill and Masood Alam).

ii) On the comparative efficiency of certain herbicides.- With a view to studying the effect of certain herbicides in different concentrations on the common weeds and on the sugarcane crop, an experiment with 12 treatments (vide table 25) was laid out. The herbicidal treatments were applied in the first week of June as foliar spray, using 280 litres of the solution per hectare in each case. The effects were as follows.

a) On mortality of weeds.- Population of weed flora was recorded with the help of a quadrat 31 cm x 31 cm thrown at random five times in each plot. Weeds coming within the quadrat were counted species-wise. The results are given in table 25. The reduction in the number of weeds due to the treatments has been expressed as per cent mortality.

Table 25

Effect of various herbicides on the mortality of weeds (16 days after treatment)

Treatment per hectare	Per cent mortality of			
	Cyperus rotundus	Sorghum halepense	Portulaca quadrifolia	Commelina bengalensis
Dowpon 5.6 kg	28.6	nil	nil	nil
Dowpon 5.6 kg twice	0.6	14.3	nil	nil
Dowpon 11.2 kg	38.8	66.7	nil	nil
Dowpon 16.8 kg	66.7	64.3	78.6	33.3
2,4-D 0.2 per cent + NaTA 11.2 kg	nil	57.9	25.0	nil
Simazin 3.35 kg	3.1	76.5	40.0	70.0
Simazin 6.7 kg	1.3	71.4	33.3	62.5
Telvar 3.35 kg	nil	53.3	50.0	50.0
Telvar 6.7 kg	nil	85.0	56.9	nil
Trash mulch	nil	nil	nil	9.5
Control (No interculture)	0.5	nil	nil	41.7
Normal interculture	10.9	96.3	nil	70.0

The dominant weeds in the field were Cyperus rotundus, Sorghum halepense, Portulaca quadrifolia and Commelina bengalensis, which together formed about 98 per cent of the total weed population. The results showed that normal interculture effected the maximum destruction of weeds. Among the herbicides, Simazin at 3.35 kg per hectare gave a better overall effect as also a fairly satisfactory destruction of Sorghum halepense, followed by Telvar, the 6.7 kg dose of which gave the highest kill of Sorghum halepense; however, the higher dose reduced the yield of cane by 6 metric tons per hectare (table 26). In general, Dowpon kept Cyperus rotundus in check better than other weed-killers and also reduced Sorghum halepense appreciably. As expected, the highest dose of Dowpon (16.8 kg per hectare) resulted in better mortality of all types of weeds than the lower doses. Splitting the 11.2 kg dose of Dowpon into two applications was found distinctly less effective than a single application. A combination of 2, 4-D and NaTA did not show any marked effect on the suppression

of weeds. Trash mulch was found to give practically no control of obnoxious weeds like Cyperus rotundus or Sorghum halepense; this may be because trash cover was laid late and the standing weeds were not removed before laying it.

b) On crop condition .- Dowpon hurt the cane crop and the ill effect was more with increasing dosage. As a result of its application, the crop showed yellowing which persisted for over 2 months after the application of the herbicide. Simazin did not show any apparent adverse effect on the crop.

c) On shoot production.- All the herbicides resulted in reduction of shoots (table 26). The deleterious effect on shoot production was the highest under Dowpon and the least with Telvar.

Table 26

Effect of certain herbicides on the shoot number, millable cane, yield and juice-quality of sugarcane

Treatment per hectare	Shoots per clump on			Millable canes in thousands per ha.	Yield in metric tons per ha.	Juice-quality in December	
	23rd June	20th July	23rd August			Pol per cent	Purity
Dowpon 5.6 kg	2.8	2.9	3.2	63.8	24.58	14.83	87.3
Dowpon 5.6 kg (twice)	2.7	2.3	2.3	43.4	13.01	14.33	85.7
Dowpon 11.2 kg	2.6	2.3	2.7	46.0	16.08	14.56	87.3
Dowpon 16.8 kg	2.3	2.3	2.7	44.7	13.85	14.59	86.4
2,4-D 0.2 per cent + NaTA 11.2 kg	2.6	3.0	3.3	73.9	30.61	15.42	88.9
Simazin 3.4 kg.	3.2	3.3	3.7	84.0	36.35	16.52	93.3
Simazin 6.7 kg.	3.0	3.5	3.9	78.6	35.44	16.38	91.3
Telvar 3.4 kg.	3.6	3.8	4.4	90.1	42.48	14.66	87.2
Telvar 6.7 kg.	3.4	3.5	4.0	84.4	36.51	15.02	86.3
Trash mulch	3.1	3.6	4.0	70.6	34.16	15.37	88.8
Control (No interculture)	3.5	3.6	3.8	86.5	40.20	15.48	88.8
Normal interculture	4.7	5.1	4.9	100.0	51.93	15.59	88.4
LSD at 5 per cent level					10.61		

4 randomised blocks; net plot-size 77 m^2; Co.S.510; planted 20th March 1961.

d) On millable canes.- The reduction in total shoots due to the treatment was reflected in the numbers of millable canes, the treated plots showing lower numbers of millable canes than the normal interculture treatment. The adverse effect was more pronounced under higher dosages of the herbicides.

e) On yield.- All the herbicidal treatments excepting 3.35 kg dose of Telvar gave significantly lower yields than normal interculture (table 26). 6.7 kg. dose of Telvar, Simazin, trash-mulch and control (no interculture) also gave lower yields, but the differences were not significant. The non-effectiveness of trash cover may be due to the fact that it was laid late and the weeds were not removed before laying. Application of Dowpon resulted in a marked reduction in yield, reduction being greater with increasing dosage. A split application of Dowpon was more deleterious than a single.

f) On juice-quality.- Application of Simazin tended to improve juice-quality, while Dowpon and Telvar treatments showed comparatively lower juice-quality than the control (P.S. Gill and Masood Alam).

6. Fertilisers and manures

i) Comparative efficiency of certain fertilisers for sugarcane.- To study the response of Complesal-Supra, aqua ammonia, urea, blood meal and guar meal to sugarcane in respect of yield and juice-quality, an experiment with 9 treatments including the unmanured control was laid out. The treatments, dosages used and the results are shown in table 27.

Table 27

Response of different fertilisers to sugarcane

Fertiliser/meal	Dose in kg per ha		Cane yield in metric tons per ha	Juice-quality in November	
	N	P_2O_5		Pol per cent	Purity
Ammonium sulphate	89	-	77.68	8.82	57.3
Ammonium sulphate + Super phosphate	89	89	72.02	8.28	58.2
Urea + Superphosphate	89	89	72.42	9.97	63.6
Aqua ammonia	89	-	72.02	8.92	67.9
Urea	89	-	71.88	9.99	59.7
Complesal-Supra	89	89	68.91	8.36	64.9
Blood meal	89	-	68.91	8.53	59.6
Guar meal	89	-	68.31	8.62	64.9
Control (unmanured)	nil	nil	68.11	10.16	67.5
LSD at 5 per cent level			2.09		

4 randomised blocks; net plot size 151 m^2; Co.975; planted 11th March 1961

Of the various fertilisers, ammonium sulphate gave the best and significant response of about 9.5 metric tons per hectare over control (table 27). Urea + super/aqua ammonia, and urea gave significantly higher yields than the control. The other fertilisers/manures gave no increases in yield. Almost all fertiliser treatments showed juice-quality inferior to the unmanured control.

ii) Comparison of nitrophosphate manufactured by O.D.D.A. and P.E.C. processes at different levels and applied to sugarcane by different methods.- At the instance of the Indian Council of Agricultural Research, an experiment to assess the comparative efficiency of nitrophosphate manufactured by two methods, viz. O.D.D.A. and P.E.C., was conducted. The fertilisers were applied at three levels of N-P_2O_5, viz. 27-27, 54-47 and [illegible] kg per hectare and three methods of application, viz. broadcast, 6.4 cm below the sett and band placement at sett level.

It will be seen from table 28 that nitrophosphate has given a slightly lower overall yield than the combination of ammonium sulphate and superphosphate, but it is as good as ammonium sulphate alone. Among the different methods of manufacture and application of nitrophosphate and the different levels there appears to be no difference (P.S. Gill and M.P. Motiwale).

7. Studies in ripening

i) Progress of ripening in cane stalk sections.- With a view to studying the progress of ripening in different parts of the cane stalk under the usual seasonal changes during the period of ripening, a series of analyses was carried out. For this purpose 25 canes (of approximately equal height) of Co.453 were cut into 5 sections after topping them 38 cm below the last transverse mark, each section being 50 to 60 cm long. Such samples were crushed weekly and their juice analysed in quadruplicate, from 14th November 1961 to 4th April 1962.

Table 28

of

Effect of process/manufacture and method of application of nitrophosphate on the yield of sugarcane

Method of application of fertiliser	Dose of Nitrogen in kg per hectare	Dose of P_2O_5 in kg per hectare	Yield in metric tons per hectare with Nitrophosphate ODDA	Nitrophosphate PEC	Am. sulphate + single superphosphate	Amm. sulphate	No fertiliser	Mean
Broadcast	27	23	68.33	60.50	63.67	-	-	64.17
2.1/2" below the sett	27	23	54.58	64.42	69.06	-	-	62.69
Band placement	27	23	52.83	64.17	58.08	-	-	58.36
Mean	27	23	58.58	63.03	63.60	-	-	61.74
Broadcast	27	-	-	-	-	59.17	-	59.17
Broadcast	54	47	70.92	65.83	54.25	-	-	63.67
2.1/2" below the sett	54	47	64.33	52.75	66.58	-	-	61.22
Band placement	54	47	44.50	66.00	76.00	-	-	62.17
Mean	54	47	59.92	61.53	65.61	-	-	62.35
Broadcast	54	-	-	-	-	61.42	-	61.42
Broadcast	107	94	47.25	64.92	75.58	-	-	62.58
2.1/2" below the sett	107	94	67.42	71.92	59.67	-	-	66.34
Band placement	107	94	67.42	57.42	78.33	-	-	67.72
Mean	107	94	60.70	64.75	71.19	-	-	65.55
Broadcast		-	-	-	-	71.33	-	71.33
Control	-	-	-	-	-	-	52.33	52.33
Broadcast	-	-	62.17	63.75	64.50	63.97	-	
2.1/2" below the sett	-	-	62.11	63.03	65.10	-	-	
Band placement	-	-	54.92	63.10	70.80	-	-	
Mean			59.73	63.10	66.81	63.97	52.33	

2 replications; 3^3 confounding factorial with 4 additional treatments; net plot size 64 m^2 ; Co.976; planted 27th February 1961.

The weekly means of the five stalk-sections plotted in fig.1 bring out the fact that under north Indian conditions, pol per cent juice does not show a steady rise. Starting at 13 per cent in mid-November, the pol shows a rapid rise for 5 weeks, but registers a sharp drop of 1 to 1.5 percentage units of pol in the 3rd week of December. Thereafter for 5 weeks it remains at a level which is for the major part distinctly lower than had been attained in mid-December. This depression is very presumably due to the cold wave which prevailed in north India in December 1961. Although this cold wave was abnormal, records of varietal trials and other earlier experiments at the Institute also show that improvement in juice-quality is usually held up in the coldest part of the year, and is resumed only about mid-January. The cold wave during 1961-62 seems to have aggravated this usual set-back.

Between 24th and 31st January, there is another depression in juice-quality, apparently due to the same reason. From the beginning of February to the end of March, there is a continuous increase in the average

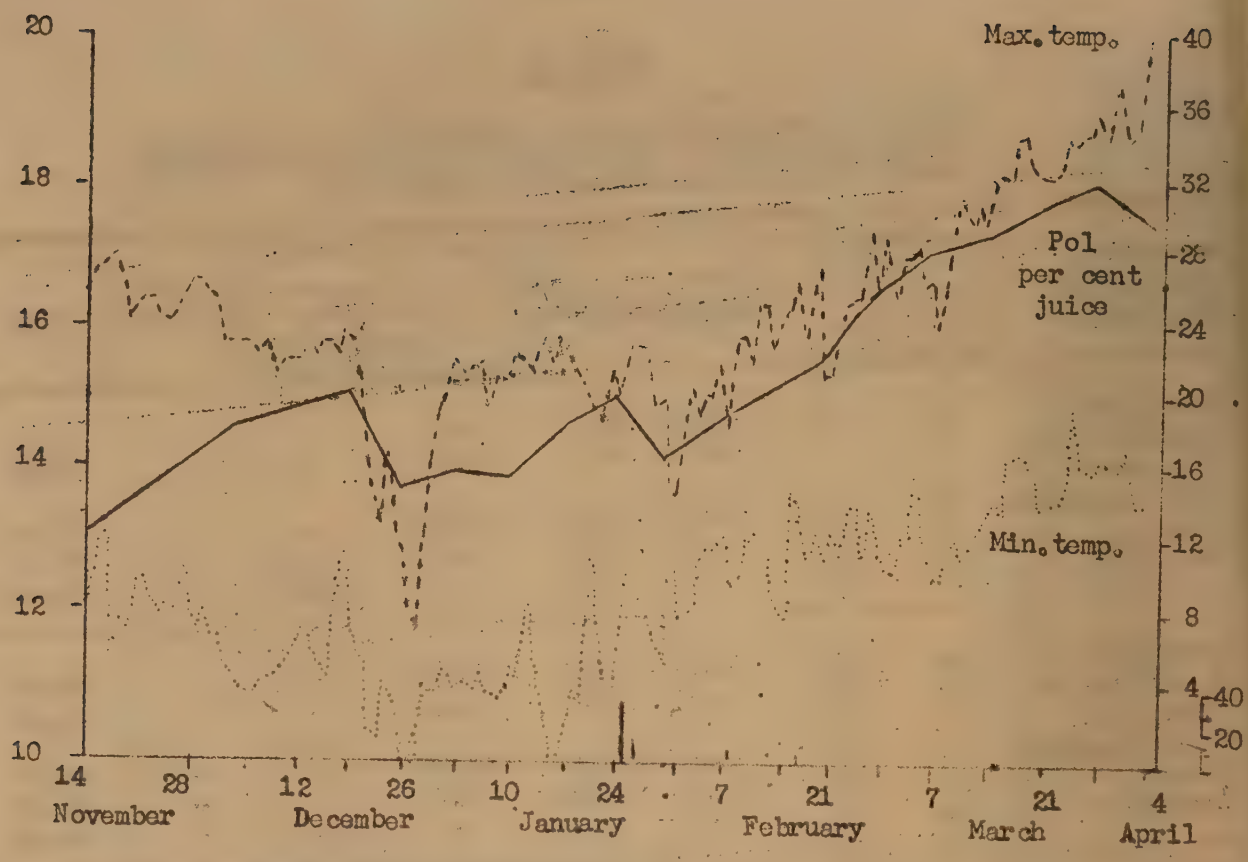


Fig.1 - Progress of ripening in a cane stalk. Ordinates: Pol per cent juice, maximum and minimum temperatures in °C and rainfall in mm. Abscissa: Dates of juice analysis.

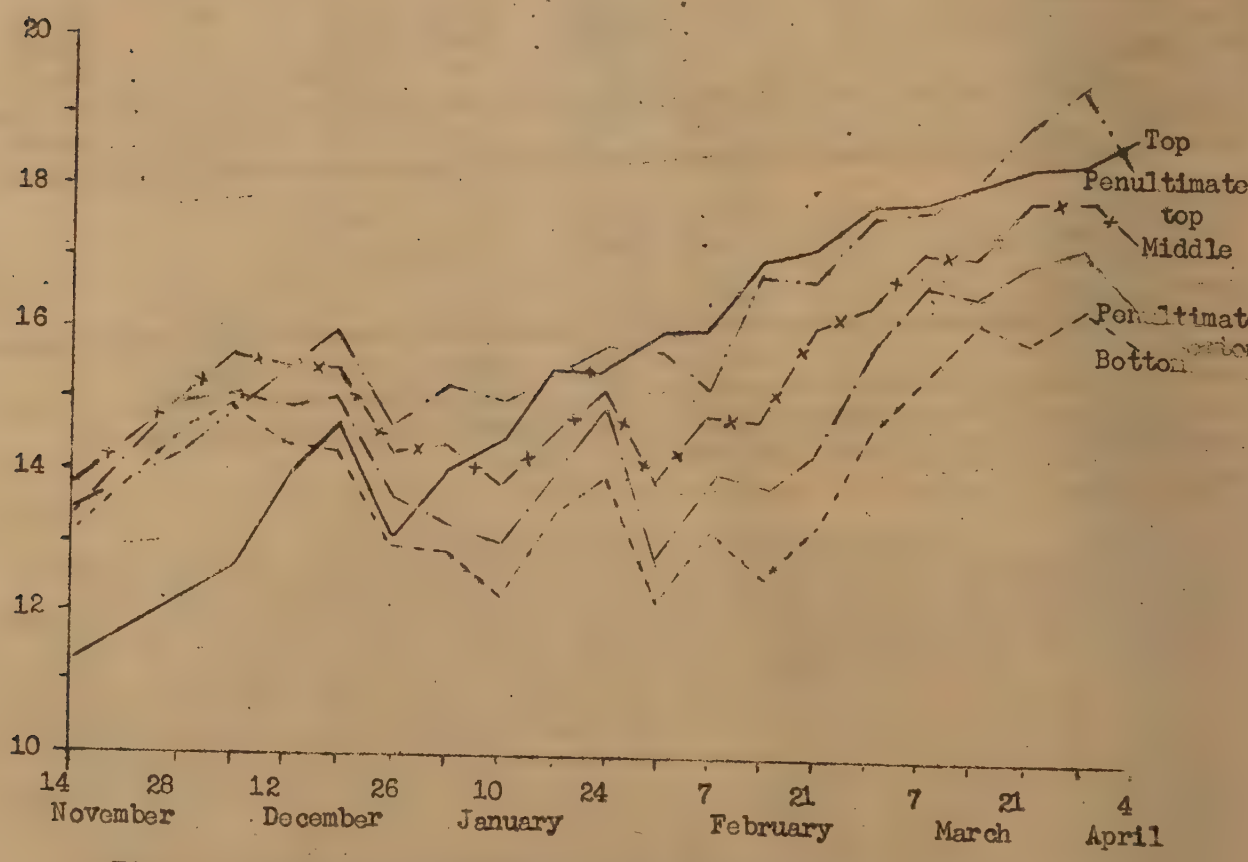


Fig.2 - Progress of ripening in cane stalk sections. Ordinate : Pol per cent juice. Abscissa: Dates of juice analysis.

pol per cent juice, at about the same rate as between mid-November and mid-December. In early April, the juice-quality starts to drop.

The sectional analysis of the cane stalk has brought out certain new and important facts (fig.2). In mid-November, the four lower sections have between 13 and 14 per cent pol in juice, while the top-section alone has a distinctly lower pol, about 11 per cent. This situation within the stalk is in conformity with the existing observation. The sections ripen more or less in this order inter se upto early December. At this stage, when the atmospheric temperatures begin to drop, the different sections behave differently. While the top sections show a rise, the successively lower sections go down in pol, the rate of fall being greater in the successively lower sections.

During the cold wave, from 22nd to 28th December, all sections of the cane show a sharp and more or less uniform drop of 1.2 to 1.5 units of pol in juice.

In the subsequent period upto 10th January when there is a partial recovery, again there is differential behaviour; the top sections tend to rise, while lower sections either maintain their quality or continue to fall, their reaction depending on their position on the stalk. A general recovery begins to take place from 10th to 24th of January.

In the week 24th to 31st January, following a rainfall of 38 mm on the 25th and 26th, there is again a sharp and short retardation. Here again, the reactions of the sections vary as described earlier. However, the two top-sections which held out during the week of rainfall, undergo what appears to be a delayed depression in the following week, by which time the lower sections begin to pick up. A similar response is observed following a shower of 4.4 mm on 7th February.

During the remaining seven weeks, all the sections rapidly improve the sugar content of their juice, maintaining their order inter se as it obtained at the end of the January depression upto the end of March. The gradient in this period is one of high quality in the top-most sections and progressively inferior quality in the successively lower sections, the reversal having occurred during the cold wave.

This pattern of distribution of pol in juice (descending gradient from top to bottom) is at variance with the pattern known to exist in cane under tropical conditions, and is also somewhat contrary to popular belief.

The periods during which juice-quality showed a general rise were characterised by a minimum temperature range of 7° to 14°C and a maximum of 23° and 32°C. The depressions in juice-quality took place when these temperatures fell to the range 0°-5°C minimum and 7°-13°C maximum respectively. In the transitional range of 5° to 7°C minimum and 15°C-19°C maximum, the various parts of the cane stalk showed differential behaviour. By the time the juice-quality reached its peak and began to fall in early April the maximum temperature had risen to nearly 40°C. However, these relationships are complex and the observations are therefore tentative.

Purity figures show changes mostly corresponding to the changes in pol. This suggests that the observed changes in pol are not due to a dilution or concentration of sap in the stalk, but are features of actual ripening and de-ripening. On the whole during crushing season, the highest purity is maintained by the penultimate top section. Towards the end of the season, all sections of the cane-stalk tend to attain the same high level of purity, although their pol percentages are in a descending order from top to bottom (R.R. Panje, P.S. Gill and Bakhtawar Singh).

ii) A review of the influence of intercrops on the juice-quality of sugarcane.- Intercropping with autumn-planted sugarcane is a useful practice, prevalent in many progressive areas and gaining ground

Table 29

Effect of intercropping on the juice-quality of sugarcane (autumn-planted or pre-seasonal)

Location and year of experimentation	Inter-crop	Pol per cent juice		Purity of juice	
		Inter-cropped cane	Non-inter-cropped cane	Inter-cropped cane	Non-inter-cropped cane
Jullundur*					
1950-52	Gram (Nov. analysis)	11.70	10.10	73.4	66.7
	(Jan.-Feb. analysis)	16.20	14.40	86.5	79.4
1951-53	" (Nov. analysis)	11.60	10.70	72.9	73.4
	(Jan.-Feb. analysis)	16.20	15.00	90.8	89.5
1952-54	" (Nov. analysis)	13.00	12.80	77.8	78.0
	(Jan.-Feb. analysis)	18.30	17.30	92.0	91.1
1953-55	" (Nov. analysis)	10.80	10.70	67.5	68.0
	(Jan.-Feb. analysis)	15.30	15.00	81.6	81.7
Shahjahanpur**					
1955-56	Gram	16.48	16.38	87.1	86.9
	Mustard	16.73	16.38	88.1	86.9
	Pea	16.75	16.38	87.5	86.9
1956-57	Gram	16.26	15.28	88.7	86.9
	Mustard	16.55	15.28	88.1	86.9
	Pea	16.83	15.28	88.9	86.9
1957-58	Gram	16.44	16.62	86.1	89.6
	Mustard	17.14	16.62	89.2	89.6
	Pea	16.76	16.62	89.3	89.6
1954-55	Gram	16.89	16.88	89.2	88.2
Rampur +					
1957-58	Pea	14.95	12.34	81.0	71.0
Neoli +					
1957-58	Pea	17.01	17.75	85.1	86.6
1958-59	Pea	16.00	15.50	88.1	88.8
Pusa +					
1955-56	Gram	16.43	15.79	-	-
	Pea	16.54	15.79	-	-
	Lentil	17.36	15.79	-	-
	Hubam clover	17.33	15.79	-	-
Lucknow ++					
1958-60	Opium-poppy	16.20	15.63	86.7	86.2
1959-61	Opium-poppy	15.59	15.47	86.1	85.1
1960-62(I)	Opium-poppy	17.78	16.90	89.4	88.3
(II)	Opium-poppy	18.23	16.33	90.5	88.6
Padegaon +					
1955-56(I-	Onion	17.56	17.45	-	-
375 lb N +	Lucerne (broadcast)	18.60	17.45	-	-
150 lb P_2O_5)	" (on sides)	18.85	17.45	-	-
	Berseem (broadcast)	18.43	17.45	-	-
	" (on sides)	18.12	17.45	-	-
(II-	Onion	17.22	18.08	-	-
450 lb N +	Lucerne (broadcast)	17.63	18.08	-	-
150 lb P_2O_5)	" (on sides)	18.42	18.08	-	-
	Berseem (broadcast)	18.16	18.08	-	-
	" (on sides)	18.12	18.08	-	-
Mean		16.52	15.86	85.2	84.0

* Singh, Harbans and Singh, Hardial, Proc. IX Cong. Int. Soc. Sug. Tech., New Delhi, I:9(1):283(1956).

** Bhoj, R.L. and Tandon, R.K., Ind. Jour. Sug. Res. & Dev., 3(2):97 (1959).

\+ Annual Reports, Sugarcane Research Scheme, U.P., Bihar and Bombay.

++ Annual Reports, Indian Institute of Sugarcane Research, Lucknow.

in parts of Uttar Pradesh and Bihar. But it is believed by some that intercrops bring down cane quality in much the same way as weeds do, and also increase the fibre content of cane, even though they compete with cane only in the early season. To find out the effect of intercropping on juice-quality the data of the experiments conducted at Jullundur, Shahjahanpur, Rampur, Neoli, Lucknow, Pusa and Padegaon, representing various climatic conditions, with different intercrops, viz. gram, mustard, pea, lentil, hubam clover, opium-poppy, onion, lucerne and berseem during the last 11 years (1950-62) were scrutinised.

The data of these research stations suggests that intercropping actually brings about an improvement in the quality. The mean increase of 39 cases is 0.7 units of pol per cent juice, and 1.2 units of purity. The improvement occurs in 35 cases out of 39. The experiment conducted at Padegaon also suggests that intercrops do not increase fibre content of the cane (Annual Report, Sugarcane Research Scheme, Bombay State, Padegaon, 1955-56, p.56).

Weeds in the spring-planted crop do not appear to exert a marked influence on the juice-quality; however with severe and prolonged competition from Sorghum halepense juice-quality is adversely affected (P.S. Gill).

8. Miscellaneous

i) Seedlings.- A total of 12,850 seedlings comprising 8 crosses was received in 1961. As the seedlings suffered dryage in transit, a majority of them failed to establish after transplanting. Of this batch, on the basis of field habit and brix by the hand refractometer 46 were selected. The selected seedlings had an average brix of 17.9 which was slightly better than the average brix of last year's batch (P.S. Gill, M.P. Motiwale and S.R. Seth).

Table 30

Selections from the 1961-batch of seedlings

Cross	No. of seedlings at maturity	No. of seedlings at maturity	Per cent seedlings selected
Co.312 x B.O.10	63	2	3.2
Co.312 x Co.S.108	148	16	10.8
Co.312 x Co.356	26	6	23.1
Co.419 x Co.356	63	13	20.6
Co.527 x B.O.17	2	nil	0.0
Co.527 x Co.453	2	nil	0.0
Co.419 x Co.S.106	27	7	25.9
Co.349 x Co.312	4	2	50.0
Total	335	46	-

ii) Preliminary test of seedlings [illegible] batch.- Fifty-two seedling varieties were selected for further testing from the 1960 batch received from Coimbatore and were planted in the preliminary test plot against Co.453 and Co.S.510 as standards. Of these, based on their agricultural and juice-quality performance, 25 were selected for the final test (P.S. Gill, M.P. Motiwale and S.R. Seth).

iii) Final test plot.- Thirty varieties selected last year from the preliminary test plot were tested against the standards Co.453 and Co.S.510. Based on the usual selection standards, ten varieties were selected. But due to change in the selection procedure of varieties for north India, these were not raised to Co. status and new varieties were

Table 31

Performance of varieties in varietal trial

Variety	Cane yield in metric tons per ha	Pol per cent juice (purity) in					Sugar in metric tons per ha.
		November	December	January	February	March	
Co.1118	65.82	9.14 (70.4)	12.29 (81.0)	13.47 (84.6)	14.32 (86.7)	15.02 (86.8)	6.78
Co.975	69.77	11.40 (76.1)	14.47 (85.9)	15.68 (87.2)	15.83 (88.1)	17.45 (89.1)	7.24
Co.1308	56.35	11.61 (77.4)	14.83 (84.3)	15.68 (85.0)	16.83 (88.9)	18.45 (87.1)	7.13
Co.1149	54.20	10.12 (74.7)	13.44 (80.9)	14.69 (84.1)	18.95 (88.5)	17.28 (88.3)	6.51
Co.1233	52.05	7.76 (62.6)	12.20 (76.3)	13.61 (79.5)	15.83 (87.8)	17.26 (85.7)	6.12
Co.S.555	50.78	12.21 (78.9)	15.75 (85.8)	16.79 (87.8)	17.46 (89.4)	18.01 (87.0)	6.28
B.O.17	50.10	10.19 (74.2)	13.65 (82.2)	14.97 (85.7)	15.85 (88.1)	17.70 (87.5)	6.10
Co.1319	49.50	10.16 (70.4)	15.24 (84.8)	15.47 (86.5)	17.41 (91.4)	18.59 (91.1)	6.40
Co.1305	48.49	12.42 (77.3)	15.79 (85.8)	16.60 (87.7)	17.31 (80.9)	19.02 (88.2)	6.37
Co.1176	47.81	11.48 (75.5)	14.17 (84.4)	15.24 (86.8)	16.74 (90.4)	17.80 (89.5)	5.92
Co.1321	47.76	13.27 (81.2)	15.50 (86.4)	16.33 (88.4)	16.44 (86.0)	18.37 (89.1)	6.09
Co.S.568	47.46	12.06 (78.9)	15.94 (86.2)	17.11 (88.8)	18.36 (91.0)	18.69 (89.4)	6.17
Co.1254	47.27	13.54 (83.3)	15.95 (88.6)	16.91 (91.1)	17.83 (91.2)	18.83 (90.8)	6.23
Co.785	45.61	13.21 (80.6)	16.01 (86.8)	17.07 (89.0)	17.75 (90.0)	19.46 (88.4)	6.14
Co.S.541	44.29	11.90 (76.9)	15.07 (83.7)	17.06 (87.2)	17.52 (87.3)	18.91 (87.1)	5.75
Co.1306	44.05	12.08 (80.9)	15.13 (88.4)	16.91 (90.0)	16.52 (91.1)	17.97 (91.4)	5.56
Co.L.29	43.36	12.82 (77.9)	16.28 (85.8)	17.19 (87.6)	17.58 (87.7)	19.15 (87.0)	5.70
Co.1155	38.19	11.88 (78.6)	16.08 (87.2)	16.59 (89.9)	17.38 (90.7)	18.29 (89.6)	4.86
C.P.49/50	35.79	12.72 (81.2)	16.07 (87.6)	19.71 (92.3)	17.78 (91.0)	19.71 (91.8)	4.96
Co.449	35.60	10.64 (75.8)	13.34 (81.6)	15.96 (88.9)	16.69 (90.3)	18.36 (90.5)	4.57
C.P.34/79	25.73	12.63 (80.5)	15.83 (86.1)	17.31 (90.3)	18.41 (90.8)	19.10 (90.0)	3.43
Co.997	25.10	12.34 (78.9)	16.61 (87.7)	17.89 (91.1)	18.89 (90.7)	20.25 (89.8)	3.54
				Standards			
Co.453	51.90	11.09 (75.5)	14.48 (82.9)	15.13 (86.8)	16.31 (88.8)	17.64 (85.7)	6.23
Co.S.510	47.95	13.35 (81.8)	15.77 (87.0)	16.32 (88.6)	17.46 (81.1)	18.40 (89.5)	6.13
LSD at 5 per cent level	8.86						

3 randomised blocks; net plot size 68 m^2; planted 16th March. 1961.

issued to Research Stations during February 1962 directly from Coimbatore. The selected varieties were multiplied to study their performance further.

iv) Trial of varieties.- Twenty-two varieties (table 31) were under trial against the standards Co.453 and Co.S.510. These include Co.449, Co.785, Co.975, Co.S.541, Co.L.29 which are under commercial cultivation in the various States and the remaining are selections from last year's varietal trial and multiplication plot. The results are shown in table 31.

Of the varieties under test Co.975, Co.1305, Co.1308, Co.1319, Co.1321, Co.S.541, Co.S.555, Co.S.568 and B.O.17 were found to combine yield and juice-quality to a satisfactory degree (Table 31). Co.785 gave good yield and good sugar content, but showed a poor field habit.

Co.1118 recorded a significantly higher yield than the standard, Co.453. However, its juice-quality was poor. Co.1149 and Co.1233 also showed similar performance. The record of Co.L.29 was passably good. Co.449, Co.1155, C.P.49/50, C.P.34/79 and Co.997 gave significantly lower yields, but showed distinctly better juice-quality than the standards. The lower yield in Co.997 during the year was accountable to heavy lodging. Co.1176, Co.1254 and Co.1306 are reported to be susceptible to red rot (P.S. Gill and J.P. Misra).

v) New varieties.- 996 varieties bearing G numbers from 16746 to 17741 were received from the Sugarcane Breeding Institute, Coimbatore during the year. The varieties were planted out for further testing (P.S. Gill, M.P. Motiwale and S.R. Seth).

vi) Live herbarium.- A total of 585 varieties were maintained in the live herbarium during the year (P.S. Gill and J.P. Misra).

AGRONOMY : SUGARBEET

(R.R. Panje: Agronomist-in-charge)

This was the third year of the project on sugarbeet cultivation at this Institute. Due to heavy and unusual rains in early October, sowings could be done only in the last week of the month. The available seed of different varieties procured in previous years was used in the sowing of the trials this year.

No major pests and diseases were observed in the crop, except a few cases of root rot; the affected plants were uprooted and destroyed to check the spread of the disease. The roots were lifted 7 months after sowing.

1. Trial of sugarbeet varieties.- Nine varieties, namely Ero, Polyro, Kw.Interpoly, A.A.R., Kw.Polybeta, Ramonskaya, US 22/3, US 35 and US 75 were tested in this trial. Ero, Polyro, US 22/3 gave very poor germination possibly because the seed in these varieties loses viability after the first year. These varieties were therefore not considered for comparison with the others.

The highest yield of beet roots was obtained with US 35(27.30 metric tons) followed US 75; Ramonskaya recorded 20.42 metric tons, but had comparatively heavier roots. The yields were lower this year because of late sowing, dryage in hot weather and also to slightly poorer germination of the old seed used.

US 35 gave the highest pol per cent roots, 15.2 in April, while the rest of the varieties recorded 12.5 to 13.7 per cent in April. All the varieties showed peak quality in May, mostly between 17 and 18 per cent pol. In the next analysis in June, the roots showed deterioration in quality ranging from 1.0 in Kw. Polybeta to 2.4 in A.A.R. (R.R. Panje, P.S. Gill and Masood Alam).

Table 32

Performance of sugarbeet varieties

Variety	Yield of roots in metric tons per hectare	No. of roots in thousands per hectare	Average weight per root in kg	Pol per cent roots in			Sugar in roots in metric tons per hectare
				April	May	June	
US 35	27.30	102.8	0.27	15.2	18.0	16.4	4.50
US 75	26.67	84.6	0.32	13.3	16.9	15.3	4.05
Ramonskaya	20.42	55.8	0.37	12.5	18.3	16.3	3.21
A.A.R.	15.09	46.1	0.33	13.0	18.3	15.9	2.37
Kw.Polybeta	14.61	49.7	0.29	13.7	18.1	17.1	2.38
Kw.Interpoly	14.67	65.5	0.22	13.5	17.1	15.4	2.25
LSD at 5 per cent level	8.15						

4 randomised blocks; plot size 100 m^2; sown 25th October 1961.

2. Fertiliser requirements of sugarbeet.- The trial was laid out with 3 leavels of nitrogen (0, 50 and 100 kg per hectare), applied as ammonium sulphate in two doses, half at sowing and half 99 days after the sowing.

Table 33

Effect of fertiliser application on sugarbeet

Level of nitrogen in kg per hectare	Yield of roots in metric tons per hectare	No. of roots in thousands per hectare	Pol per cent roots in May
0	14.38	113.5	18.2
50	14.83	111.0	18.2
100	15.06	96.6	17.2
S.E.	0.38		

6 randomised blocks; plot size 107 m^2; US 35; sown 29th October 1961.

With the progressive increase in the level of nitrogen a slight increase in yield of roots was observed; the differences were however non significant (R.R. Panje, P.S. Gill and Masood Alam).

3. Irrigational requirements of sugarbeet.- An experiment with 3 levels of irrigation, (5, 7 and 9 irrigations), was carried out. Germination was not quite satisfactory and the stand of the crop was somewhat thin in all the plots.

Table 34

Effect of irrigation levels on sugarbeet

No. of irrigations	Yield of roots in metric tons per hectare	No. of roots in thousands per hectare	Pol per cent roots in May
5	8.55	38.8	17.4
7	10.48	45.1	16.1
9	15.83	56.3	16.1
LSD at 5 per cent level	2.16		

6 randomised blocks; plot size 107 m^2; Ramonskaya sown 28th October 1961.

There was a direct response to irrigations. 9 irrigations gave 3.35 metric tons more yield of roots per hectare than 7 irrigations and these in turn yielded 1.93 metric tons more yield than 5 irrigations (R.R. Panje, P.S. Gill and Masood Alam).

3. Seed production.- Some plants of US 22/3 and US 35 sown in October flowered in late March and early April, respectively. A few grams of sugarbeet seed was collected from US 22/3, and was found viable in a laboratory test (R.R. Panje, P.S. Gill and Masood Alam).

4. Comparison between dibbling of seed and transplanting of seedlings.- A small-scale unreplicated test to compare the relative merits of dibbling of seed and transplanting of seedlings, i) on ridges, ii) on flat and iii) in furrows was conducted with variety Ero. 6-week old sugarbeet seedlings were used for transplanting. Dibbling of seed and transplanting of seedlings were done on 27th October 1961. The outturn from transplanted sugarbeet seedlings was on the average twice as much as that from seed dibbled directly. The quality of roots from transplanted seedlings was also slightly better. Of the different ways of transplanting, seedlings transplanted on flat and in furrows showed better performance than those transplanted on ridges.

The advantage of transplanting over direct dibbling is very striking, but is not being expressed in yield per acre, as the germination of the dibbled seed was not satisfactory. The roots of the transplanted seedling were bigger. Transplanting did not appear to affect the shape of the roots. The results need confirmation in replicated trials with adequate plot size (R.R. Panje, P.S. Gill and Masood Alam).

5. Soil moisture content and germination of seed balls.- It was observed that sugarbeet seeds failed to germinate satisfactorily when sown in soil with a moisture-content of 15 per cent, and that under Lucknow conditions, to obtain good germination, irrigations after sowing were necessary (R.R. Panje, P.S. Gill and Masood Alam).

STATISTICS

The designing of the various experiments of the Institute, their analyses and interpretation by the appropriate statistical methods continued to be the major work of this section. Along with this, the viability distribution among the buds of the stalk and the relative change therein when the stalk is cut into three-budded setts was also examined. From the stalk borer incidence data, the comparative efficiencies of different sampling units for simple random sampling were found out. The influence of the meteorological factors preceding the harvest of the sugarcane crop on the recovery per cent was also studied.

Viability Distribution: The data pertaining to the observed number of the germinated buds on single-budded setts of 389 stalks of Co.997 planted in the serial order under uniform external conditions in March, 1960 were scrutinized for examining the viability distribution. The values of β_1 and β_2 as found out from the data on the observed number of the germinated buds at each location on equal-budded stalks are very nearly zero and two respectively. The Type II Pearsonian curve pertaining to this combination of β_1 and β_2 was fitted to the observations. The expected frequencies from the empirical curves together with their Chi-square values and their parameters are shown in table 35.

The agreement between the observed and the expected values is very high which suggests that the viability distribution with respect to germination frequency belongs to the Type II curve of the Pearsonian System.

Germination data of serial three-budded setts of 15-and 18-budded stalks were analysed to find out the influence of sett-cutting on the

Table 35

Expected numbers of buds germinated in stalks having the different number of buds

Location of the buds from the top	Number of buds on the cane												
	10	11	12	13	14	15	16	17	18	19	20	21	22
1	2	6	7	11	3	8	7	1	6	8	4	5	6
2	7	11	11	9	7	10	9	7	11	10	9	8	8
3	9	15	13	11	11	13	10	9	12	12	12	9	10
4	11	18	15	12	13	15	12	11	15	14	14	11	11
5	11	19	16	13	14	17	12	13	17	15	16	12	12
6	12	20	17	14	15	17	13	14	18	15	17	13	13
7	12	20	17	14	16	18	13	14	13	16	18	13	13
8	11	19	17	14	16	18	14	15	19	17	18	13	14
9	11	18	16	14	16	18	14	15	19	17	19	14	14
10	10	16	15	14	16	18	13	15	19	17	19	14	14
11		13	13	13	15	17	13	15	19	17	19	14	14
12			10	12	14	16	12	14	19	17	19	14	14
13				10	12	15	11	14	18	16	18	14	14
14					9	13	10	13	17	16	18	13	14
15						17	9	11	16	15	17	13	14
16							10	9	14	14	16	12	13
17								7	11	12	14	11	13
18									15	10	12	10	12
19										8	9	9	11
20											3	7	10
21												4	8
22													6
χ^2 value	4.46	6.24	3.29	5.31	3.37	5.09	3.04	4.60	6.46	6.40	11.64	5.26	5.60
d.f.	7	9	10	11	11	13	14	14	16	17	16	17	20
Significance higher than	80%	70%	97%	90%	99%	95%	99%	99%	97%	99%	80%	99%	99%
Parameters ± m	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
a	5.2	5.7	6.2	7.2	7.0	8.1	8.6	8.4	9.3	10.1	9.7	10.5	11.5
y_o	11.76	19.89	17.15	14.25	16.11	18.09	13.63	14.94	19.38	16.92	18.91	14.19	14.31

viability distribution. For it the data on the observed number of germinated top, middle, and bottom buds on the sett were considered and the values of β_1 and β_2 accruing from all the series were found to be very nearly zero and two respectively. This shows that the inherent nature of viability distribution has not changed. The expected values and parameters on Type II distribution are shown in table 36.

The agreement between the observed and the theoretical values by Chi —square is very close. The viability is highest at the middle bud, followed by the top and the bottom buds. The shares of total viability taken by these three locations are very nearly constant for setts of all categories of stalks .

Stalk borer incidence: Incidence is defined as the proportion of the infested stalks to the total population. The normal sampling procedure for estimating this proportion will be valid (a) if each stalk is considered a sampling unit capable of classification into an infested stalk or not, or (b) if the sampling units are such that each of them contains the same number of stalks. The practical exigencies of the situation neither permit the stalks to be considered as the sampling units,nor can such units be found each of which may contain the same number of stalks. The alternatives left are either to consider the ratio

Table 36

Expected numbers of germinated top, middle and bottom buds on the three-budded setts

Location of the sett on the stalk	October planting five-sett stalks			October planting six-sett stalks			February planting five-sett stalks		
	Top	Middle	Bottom	Top	Middle	Bottom	Top	Middle	Bottom
1	61	87	56	28	37	22	34	47	24
2	87	112	63	38	50	26	46	55	30
3	94	121	65	41	55	27	49	59	32
4	86	112	59	41	54	27	46	56	29
5	60	88	44	36	48	24	34	47	21
6				25	37	17			
χ^2 value	5.84	2.91	4.05	9.46	2.17	2.36	1.84	2.66	1.93
d.f.	4	4	4	5	5	5	4	4	4
Significance greater than	20%	50%	40%	90%	80%	79%	75%	60%	75%
m	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Parameters ±a	7.92	8.21	8.30	9.58	9.70	10.21	8.24	8.49	8.23
y_0	93.5	120.8	65.8	41.7	55.3	27.7	49.1	59.4	31.6

estimate if the conditions for its being best unbiased linear estimate are satisfied, or to consider the infested and the total stalk populations separately. The former alternative was examined in some detail as reported earlier. This year the studies on the two populations were made separately.

Table 37

The means and the variances of the infested and total canes in row cuts of varying lengths

ngth of mpling it in et	N	1954-55				N	1957-1958			
		Infested canes		Total canes			Infested canes		Total canes	
		Mean	Variance	Mean	Variance		Mean	Variance	Mean	Variance
1	371	1.09	1.299	3.79	5.543	262	1.90	4.027	3.84	6.254
2	236	1.71	2.567	5.96	11.398	205	2.43	5.786	4.90	10.394
3	162	2.49	4.022	8.62	15.196	153	3.08	7.212	6.31	13.968
4	123	3.31	6.116	11.33	22.043	117	4.02	10.455	8.21	20.716
5	99	4.08	7.044	14.24	21.800	96	4.76	12.686	9.53	23.294
6	82	4.94	9.311	17.11	29.073	79	5.63	14.214	11.63	24.022
7	70	5.77	12.405	20.10	35.861	69	6.72	19.358	13.58	35.838
8	61	6.62	18.268	22.67	45.139	61	7.72	17.120	16.18	38.540
9	55	7.35	16.953	25.40	53.876	55	9.05	29.910	17.83	45.610
10	49	8.20	18.122	28.31	53.151	49	9.88	29.290	19.65	40.635
11	45	8.98	21.355	31.27	48.862	45	10.53	36.855	22.31	55.330

Stalk borer incidence data for 1954-55 and 1957-58 were examined. The distribution of the infested and total stalks in 1-ft. to 11-ft. cuts of rows of the plot were examined. The cuts from gaps in rows were left out.

It is found from table 37 that both the means and variances have increased with the size of unit.

Table 38

Comparative sample sizes for the same precision and the relative net precision for the same cost

Length of sampling unit in feet	1954-1955				1957-58			
	Infested canes		Total canes		Infested canes		Total canes	
	Sample size	Relative precision	Sample size	Relative precision	Sample size	Relative precision	Sample size	Relative precision
1	1	100	1	100	1	100	1	100
2	1.599	115	1.664	111	1.759	105	2.035	90
3	1.771	135	1.568	153	1.833	131	2.285	105
4	2.070	93	1.748	110	2.072	93	2.643	73
5	1.920	135	1.400	186	2.116	123	2.501	104
6	2.100	114	1.536	156	1.925	125	2.095	114
7	2.380	53	1.612	156	2.335	108	2.784	90
8	3.038	84	1.759	145	1.843	139	2.672	96
9	2.584	48	1.821	138	2.948	85	2.894	87
10	2.441	82	1.678	119	2.546	79	2.274	88
11	2.659	66	1.426	123	2.970	59	2.871	61

In table 38 the sample size for each unit giving the same precision have been found out; the efficiencies of these sampling units in relation to the time consumed in sampling show that 5- and 6-ft. units are the best both for infested and total stalks. The conclusion is tentative.

Meteorological factors and sucrose recovery

To study the effect of the meteorological conditions preceding the harvest of sugarcane on the recovery per cent, correlations were worked out between the recovery data of Sardarnagar factory for 1957-58 and the weekly data of maximum temperature, minimum temperature and the relative humidity.

Table 39

Correlation coefficients and z values between the preceding weekly mean meteorological data and the recovery per cent at Sardarnagar factory for the year 1957-58

Week preceding the recovery week	Maximum temperature		Minimum temperature		Relative humidity		Difference (Max. temp.-Min. temp.)	
	Corr. coeff.	z	Corr. coeff.	z	Corr. coeff.	z	Corr. coeff.	z
8th	-.668	-.845	-.667	-.805	.458	.495	-.020	.020
7th	-.689	-.845	-.670	-.810	.405	.430	-.020	.020
6th	-.693	-.850	-.643	-.763	.325	.343	-.140	.139
5th	-.754	-.983	-.724	-.923	.413	.441	-.370	.354
4th	-.716	-.901	-.781	-1.052	.228	.232	-.285	.278
3rd	-.638	-.755	-.681	-.831	-.042	-.042	-.190	.188
2nd	-.421	-.451	-.436	-.468	-.276	-.283	-.061	.061

It is found (table 39) that for the maximum and minimum temperatures, the correlation coefficients with the preceding maximum and minimum temperatures are negative, high and significant. For humidity, however, the values are very small. The correlation of the difference between maximum and minimum temperatures with the recovery per cent, is low.

The correlation coefficients for the three meteorological fac-

tors rise or remain constant for a time, and decline as the period between the observation and the harvest lessens. It was found by z-transformation that if the within-week variations are negligible, the correlation values for the preceding 8 to 4 weeks are significantly different from 3 weeks. This indicates that for recovery meteorological factors of the preceding three weeks are of lesser consequence than those of the earlier periods.

Partial correlations between maximum and minimum temperatures are high and positive. The correlation between maximum temperature and relative humidity though always negative is not high enough, and that between minimum temperature and relative humidity is not even consistent. This, suggests that a prediction formula for recovery might be available by only considering either the maximum or the minimum temperature along with relative humidity. The multiple correlations(table 40) show that about 60 per cent variation in recovery is accounted for by these two factors; and the weather conditions of the 5th preceding week have the maximum influence controlling the variation to the extent of 75 per cent.

Table 40

Multiple correlations showing the agreement between observed and the predicted recovery at Sardarnagar factory

Weeks preceding the recovery week	Correlation coefficient between recovery observed and recovery predicted on basis of	
	Maximum temperature and relative humidity	Minimum temperature and relative humidity
8th	.765	.773
7th	.776	.785
6th	.753	.770
5th	.824	.868
4th	.760	.854

AGRICULTURAL CHEMISTRY AND SOIL SCIENCE

(Ambika Singh : Soil Chemist)

1. Modus operandi of green manuring for sugarcane in north India

In last year's report, yield data were presented from this experiment. The conclusion was that the increase in yield of sugarcane as a result of green manuring was not commensurate with the amount of carbon and nitrogen buried in the soil in green manuring crops. As these findings were unexpected, data from green manuring experiments conducted earlier by State experiment stations were also critically examined and interpreted in the light of the results of the Indian Institute of Sugarcane Research experiments. The data utilised in this analysis were from Shahjahanpur (1936-39), Jullundur (1953-57), Muzaffarnagar (1936-40) and Kalai (1936-39). The Shahjahanpur and Jullundur data have shown that (a) by sunn green manuring, one could expect 20-40 per cent increase in the yield of sugarcane in Punjab and Uttar Pradesh, (b) the contribution of the underground parts of the sunn in the total yield increase is 40-50 per cent, and (c) the manurial value of green crop ploughed-in is not directly related to the amount of nitrogen and organic matter ploughed-in. Further the experiments at Muzaffarnagar have shown that roots are themselves sufficient to provide about 50 per cent of total benefit from green manuring, and that fibre can be extracted from the aboveground portion of the sunn crop and the leaves added to the soil; alternatively seed can be taken from the sunn crop. In this experiment whole sunn ploughed-in gave a cane yield increase of 27 per cent over cotton-fallow; when fibre was taken from the above-ground portion a similar increase in yield was obtained. Even when sunn was grown for seed, the decrease from the difference due to whole sunn treatment was only 3 per cent. This could possibly be accounted for by the presumption that roots in this case became harder and desiccated, and a part of their nitrogen was mobilised to the point where demand for nitrogen was highest. The most interesting point of this experiment is that with all this, the roots of sunn plants seem to have left or brought about a fertilising effect and this effect lasts at least up to the first ratoon. In the first year, cotton-metha* and cotton-pea treatments gave 9 and 4 per cent increases over the cotton-fallow treatment respectively, but in the ratoon crop there was a 13 per cent increase. Similarly in the ratoon crop, when more roots of sunn were added, there were increases of 18 and 16 per cent respectively as compared to the 14 per cent increase in sunn green manure treatment.

To sum up, the increase in yield of cane following green manuring with sunn is not commensurate with the nitrogen and organic matter added to the soil in the green top. This finding has opened up certain new concepts regarding the role of green manuring to sugarcane. They are being investigated in laboratory and field experiments (Ambika Singh).

2. Comparative cumulative effects of manures and chemical fertilisers on sugarcane crops and soil

The efficiency of nitrogen applied to the sugarcane crop as farmyard manure is much lower than that of inorganic fertilisers and yet organic sources of nitrogen are recommended in manurial schedules of sugarcane in all States of the Union. Apart from the fertility which could be secured through chemical fertilisers, the crop-producing capacity of a soil depends on its physical condition which governs the water and air supply to the roots. Organic manures have been recommended for keeping the soils inter alia in a good physical condition. Recent studies on the turn over of organic matter in the soil and the role of organic manures in maintaining the organic matter content of soil consistent with good tilth has raised these questions. A long-term experiment with the following treatments has therefore been initiated at the Institute. The treatments are

1) No manure or fertiliser (control) (0).

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* Trigonella foenum-graecum

2. Nitrogen at the rate of 112 kg N per hectare as ammonium sulphate (N).
3. Nitrogen at the rate of 224 kg N per hectare as ammonium sulphate (NN).
4. Phosphorus at the rate of 112 kg P_2O_5 as single superphosphate (P).
5. Potassium at the rate of 112 kg K_2O as sulphate of potash (K).
6. A combination of treatments 3 and 4 (NNP).
7. A combination of treatments 4 and 5 (PK).
8. A combination of treatments 5 and 6 (NNPK).
9. Farmyard manure to supply nutrient equivalent of treatments 2 and 7; all nitrogen in the form of manure, and amount of P and K adjusted through inorganic fertilisers (M).
10. Farmyard manure equivalent of treatment 8. The amount of P and K was adjusted through inorganic fertiliser (MM).

On the basis of experience gained in the permanent manurial trial of the Sugarcane Research Station, Shahjahanpur, two varieties namely Co.997 and Co.975 have been used in this study. The rotation to be followed is mono-culture of sugarcane (sugarcane-ratoon). In order to have one plant and one ratoon crop every year three fields have been earmarked for the experiment.

The full doses of phosphorus, potassium and the farmyard manure were applied in the respective treatments at planting time. Ammonium sulphate was applied in two doses, one at the planting and the other with the irrigation in June. Superphosphate was applied in furrows below the setts, while the other fertilisers and manures were broadcast.

During the year the yield in the experimental treatments was

Table 41

Germination per cent, yield and juice-quality of cane as affected by different fertilisers and manures

Treatment	Germination per cent	Yield of cane quintals per hectare	Juice-quality		
			Brix	Pol per cent	Purity
0	51.3	499	18.9	17.80	91.5
N	50.6	429	19.2	17.66	92.1
NN	51.3	513	19.5	17.78	89.4
P	67.3	406	20.3	18.55	91.1
K	47.0	458	20.1	18.03	89.9
PK	65.6	386	19.3	16.89	87.5
NNP	54.6	453	19.6	18.01	92.1
NNPK	46.3	470	19.8	18.12	91.1
M	59.0	545	19.7	18.19	91.0
MM	64.6	516	20.1	18.20	90.5
0	63.0	489	18.5	16.58	89.1
N	62.0	630	18.5	16.31	89.3
NN	51.6	511	17.2	15.31	84.0
P	59.3	470	17.6	15.60	88.4
K	49.0	575	18.9	17.15	90.6
PK	54.0	541	18.9	17.24	91.0
NNP	59.0	493	17.7	15.63	88.5
NNPK	52.6	606	17.9	15.39	89.9
M	65.3	572	18.5	18.90	87.9
MM	64.6	545	19.6	17.43	88.2
LSD at 5 per cent		Not sig.	Not sig.	Not sig.	
Co.975		543			
Co.997		467			
LSD at 5 per cent		25.5			

not significantly affected by application of the fertilisers. The yield of Co.975 was significantly higher than that of Co.997. The juice-quality also did not show any consistent trend with the treatments.

The field was patchy and the crop could not get enough irrigation during the summer months. Apparently the benefit of fertiliser application could not be secured (Ambika Singh and S.N. Pandit).

Yield trend of the long-term experiment at Sugarcane Research Station, Muzaffarnagar.- As an adjunct to above experiment, the yield data from a long-term manurial experiment conducted at Muzaffarnagar were analysed. Soil samples were also taken from selected plots of this experiment for the analysis of soil pH, organic matter, total nitrogen and soil aggregation. This experiment has been in progress since 1949-50 in a monoculture rotation of sugarcane in two fields alternately. There are seven treatments in complete randomised blocks, namely, i) control (no nitrogen), ii) farmyard manure (132 kg N per hectare), iii) groundnut cake (132 kg N per hectare), iv) ammonium sulphate (132 kg N per hectare), v) farmyard manure (66 kg N per hectare) + ammonium sulphate (66 kg N per hectare), vi) groundnut cake (66 kg N per hectare) + ammonium sulphate (66 kg N per hectare) and vii) farmyard manure (44 kg N per hectare) + groundnut cake (47 kg N per hectare) + ammonium sulphate (44 kg N per hectare).

Cane has responded to nitrogen in all the three forms. The average per cent increases, due to application of nitrogen as farmyard manure, groundnut cake and sulphate of ammonia are 24, 34 and 48 per cent respectively. When half the nitrogen in each case is given as ammonium sulphate and the other half is given either as farmyard manure or as groundnut cake, the resultant responses are the sum of the separate contributions of each of the sources. Similarly, when the total dose of nitrogen is given equally from three sources the yield again shows no interaction, and is sum of the responses of individual sources.

The regression of yield on years was therefore worked out for the four of the treatments only, viz. control (no nitrogen), farmyard manure, groundnut cake and ammonium sulphate. The analysis showed that neither the linear nor the higher regressions were significant. This indicates that the yields have no trend with years. The variations appear to be due to factors other than the fertiliser treatments.

In view of the above, the effect of these treatments on the soil was investigated by analysing the soil for pH, organic carbon and nitrogen. The results are given in table 42.

Table 42

pH, organic carbon and nitrogen content of soils of plots to which nitrogen of different sources had been applied in the long-term manurial trial of the Sugarcane Research Station, Muzaffarnagar

Treatment	Field no. A2			Field no. A5		
	pH	Organic carbon per cent	Nitrogen per cent	pH	Organic carbon per cent	Nitrogen per cent
Control (no nitrogen)	7.8	0.28	0.035	7.8	0.26	0.031
Farmyard manure	7.7	0.28	0.042	7.8	0.36*	0.043
Groundnut cake	7.7	0.25	0.042	7.8	0.27	0.035
Ammonium sulphate	7.5	0.28	0.036	7.7	0.28	0.036

* sample taken after the application of farmyard manure and before planting cane.

The pH of the soil treated with ammonium sulphate has not gone down to any appreciable extent, even after 7 biennial applications of the

fertiliser. The carbon content of the soil also does not seem to have been built up to any extent through farmyard manuring. The high value of carbon obtained in field no. A5 was due to the manure having been applied in the field just prior to taking the sample. With sufficient time for its decomposition, this value would also presumably reach the steady value as in field no.A2. The nitrogen content of farmyard manure-treated plots is higher than that of the other plots, but the build-up is not so spectacular as to make marked difference to the production capacity of the soil. Thus it seems that chemically the soil has not improved to any appreciable extent by the continuous,application of farmyard manure, nor has the fertility of plots treated with ammonium sulphate gone down to any extent.

The data on the aggregation of soil of treated plots are given in table 43.

Table 43

Effect of long-term application of different forms of nitrogen on the aggregation of sugarcane soil

Treatment	Per cent aggregates bigger than 0.25 mm
Control (no nitrogen)	21.6
Farmyard manure	36.8
Groundnut cake	35.8
Ammonium sulphate	30.7

As could be expected the farmyard manure-treated plots have a higher per cent of aggregates than the other treatments, but here again in ammonium sulphate-treated plots the per cent aggregates bigger than 0.25 are not much less than those of farmyard manure-treated plots.

To sum up, by the continuous application of ammonium sulphate, neither the pH nor the organic carbon, nor the nitrogen content of the soil have decreased to such an extent as would make the soil infertile. On the contrary, the yields on these plots have been higher than those of the other treatments, and the differences have been maintained (Ambika Singh).

3. Effect of nitrophosphates on uptake of P by cane

Nitrophosphates produced by CDDA and PEC processes were compared with superphosphate as a source of phosphorus for sugarcane. A field experiment having three sources of phosphorus at three levels and three methods of placement was conducted by the Agronomy Section (For yield, juice-quality and other relevant data please see page 37).

Three months after planting, the growing leaf-sheaths (3rd, 4th, 5th and 6th) were sampled for the determination of phosphorus.

The data presented in table indicate that the level of phosphorus in cane was unaffected by the factors under test, namely sources, doses and methods of placement.

Sugarcane appeared to absorb slightly more phosphorus from nitrophosphates, both produced by ODDA and PEC processes, but the differences were not statistically significant. The higher uptake with the 48 kg dose of phosphorus was non-significant. Neither methods of placement, nor the levels of nitrogen made any difference. As in other experiments conducted in the past at this Institute, sugarcane did not show any response to P in yield or the phosphorus content of the index tissue. The factors responsible for these remain yet to be investigated (Ambika Singh and S.S. Iyer).

Table 44

Effect of sources, doses and methods of placement of phosphorus on the phosphorus-content of leaf-sheaths

Particulars	P in leaf-sheath per cent	Significance
Phosphate treatments		
Single superphosphate	0.193	
ODDA nitrophosphate	0.198	Not significant
PEC nitrophosphate	0.213	
Doses of P in kg per hectare		
24	0.188	
48	0.212	Not significant
72	0.203	
Methods of placement		
Broadcast	0.195	
5 cm below sett	0.210	Not significant
Band placement	0.199	
Doses of N in kg per hectare		
0	0.203	
27	0.197	Not significant
54	0.190	
108	0.218	

4. Aqua ammonia as a source of nitrogen

Aqua ammonia was applied to cane at the rate of 67 kg nitrogen per hectare in irrigation water in May. The design was paired plots with aqua ammonia and no nitrogen treatment. The aqua ammonia plots gave an average yield of 416 quintals per hectare against 349 in the control.

The experiment has shown that aqua ammonia can be used as a fertiliser and may be expected to yield about 1 quintal per hectare of cane for every kg of nitrogen applied (Ambika Singh and R. Singh).

5. Leaf yellowing in sugarcane

During the past few years it has been noticed that sugarcane crop in many fields of the Institute showed symptoms of yellowing of leaves accompanied by slowing down of growth, and a lowered yield. The yellowing usually started soon after the break of monsoon and though the crop sometimes improved later in the season and healthy leaves emerged, the leaves which had already started yellowing did not generally recover. This year these symptoms were seen in a ratoon crop of Co.527 and to a lesser extent in plant crops of Co.975 and Co.1107. The varieties Co.453, Co.1111, Co.976 were free from this ailment. The main observations taken were i) that the condition occurred in certain varieties much more than it did in others, ii) that its intensity varied in different areas in different fields, and iii) that it affected the crop in patches.

In order to find out remedial measures, application of a) nitrogen as a ammonium sulphate, b) of superphosphate, c) potassium

sulphate, and d) spraying leaves with ferrous sulphate solution were tried, but these proved ineffective. The N, P and K content of leaf samples from affected plants were found to be lower than those of the healthy plants. A small field experiment was laid out with Co.527 with following treatments: (H_1) setts from apparently healthy canes in affected patches, (H_2) setts from apparently healthy canes, from unaffected fields, and, (D) setts from affected canes. In each case, setts top portions (T) were taken separately from those of the bottom (B). The seed material so classified, was planted in unreplicated plots in February 1962. The data on the population of cane in different treatments are given in table. They indicate that this condition affects the germination and tillering of the plants raised from affected seed material.

Table 45

Effect of the seed material from the affected and healthy cane on the germination and tillering of sugarcane buds

Seed material from		Number of plants out of 18 buds planted as on 17th April 1962	as on 4th June 1962
pparently healthy canes rom affected patches	Top portion	10	50
	Bottom portion	10	47
pparently healthy canes rom affected field	Top portion	10	91
	Bottom portion	9	112
ffected canes from ffected patches	Top portion	10	21
	Bottom portion	5	17

Observations are continuing (Ambika Singh and R. Singh).

6. Preliminary investigations on the effect of some soil physical factors on the yield of cane

Last year, the nature of unproductive soil patches in the Institute farm area was investigated and it was found that many patches had a very hard compacted sub-soil, bulk density of some of the patches being as high as 1.76 as against 1.0 in the ordinary cultivated top soil. Consequently, the root spread was restricted to the surface. This year, the root systems of four clumps from unproductive patches and productive soils were exposed. The horizontal and vertical spread of roots was recorded on graph paper in photographs of the profile. The root spread data indicated very clearly that on unproductive patches, sugarcane plants had very few roots and they were confined to the top 45 cm. of the soil. Because of this restricted root system, the plants were able to tap only a small soil volume. Consequently the crop on such patches was poor. Data on the physical properties of these patches are being collected (Ambika Singh).

7. Phosphorus deficiency of cane

In a preliminary study on the phosphorus nutrition of cane, phosphorus deficiency was produced in cane raised in a quartz sand-culture. In the first year, single-budded sugarcane setts of Co.453 were grown in a phosphorus-deficient culture-solution for four months. The cane setts from these were planted again in P-deficient sand-culture. The crop while being grown to maturity developed characteristic phosphorus deficiency symptoms. Different tissues were then analysed for the level of phosphorus (table 46).

Table 46

Phosphorus content of different tissues of cane grown in complete and P-deficient nutrient solution

Tissue	Phosphorus per cent dry matter of plants raised in	
	Complete nutrient solution	Phosphorus-deficient solution
Spindle cluster	0.60	0.28
Elongating blade	0.42	0.18
Elongating leaf-sheath	0.32	0.12
Top 4 internodes	0.29	0.09

The data show that marked deficiencies have been brought about in the material developed. Samples of tissues were taken for the analysis of different fractions of nitrogen in normal and phosphorus-deficient plants. The analyses are in progress (Ambika Singh and S.M. Jafri).

8. Antagonistic effect of B. subtilis on Azotobactor vinelandii Lip.

While studying the bacterial populations in the green manuring experiment, a zone of lysis was observed around the colony of a bacterium. The organism showing antagonistic effect was later identified as Bacillus subtilis in the microbiological laboratory of the Indian Institute of Science, Bangalore. This organism has already been recorded to exercise antagonistic effect on positive and gram negative organisms. The effect of the isolated bacterium was studied on Azotobacter vinelandii, a non-symbiotic nitrogen-fixing soil organism.

The cultures were maintained on beef-extract peptone-agar slants. The culture filtrate was obtained from the broth after three days' incubation at 37°C. Its effect was studied by cup assay.

Table 47

Inhibition of Azotobacter vinelandii Lip. on B. subtilis

Treatments	Mean diameter of zone of inhibition in mm (mean of 3 readings)
Control	nil
Filtrate 2 days	19.3
Filtrate 3 days	19.6

The data (table 47) show that B. subtilis has considerable inhibitory effect on Azotobacter vinelandii. The actual principle is an excretory product. Studies on the chemical nature of the active agent and its associated properties are in progress. (D.P. Johari and Ambika Singh).

9. Physiological, ecological and biochemical studies on Rhizobium spp.

Pot-culture studies were done with 6 strains each of gram and pea for testing the efficiency of the strains for nodulation and nitrogen-fixation. The percentage of nitrogen fixed calculated on oven-dry basis by the strains were as follows: G(c):0.70; GRh:1.82; GRh_2:2.10;

GRh_3:2.38; GRh_4:1.82; GRh_5:0.70; GRh_6:1.54; P(c):0.84; PRh_1:0.70; PRh_2:1.68; PRh_3:1.12; PRh_4:3.08; PRh_5:0.84; PRh_6:1.96 (G: gram; P: pea; C: control; Rh: Rhizobium strain).

In the case of gram, all the strains except GRh_5 gave increased percentage of nitrogen in the plant. The strain GRh_5 was ineffective. The highest nitrogen fixation efficiency was recorded by GRh_3. Among the pea strains, PRh_1 and PRh_5, registered a lower amount of fixed nitrogen. The other strains were effective and efficient, particularly PRh_4 (D.P. Johari and Ambika Singh).

PHYSIOLOGY

(Dr. T. Raja Rao : Physiologist)

1. Studies on the prevention of flowering

1) Effect of defoliation on the flowering, cane yield and juice-quality of Co.1207 and Co.1062.- The preliminary experiments conducted last year with Co.1207 and Co.1062 had shown that in these two varieties, flowering could be suppressed by defoliating the stalks on any day or days in the 2nd and 3rd weeks of September. This year's experiment was conducted for the confirmation of these results and also to study the effect of flower suppression by defoliation on the yield of cane and quality of juice of these varieties. The treatments were (i) defoliation on 16th September (ii) defoliation on 24th September and (iii) control (undefoliated).

Table 48

Percentage of flowering in Co.1207 and Co.1062 as influenced by defoliation*

Treatments	Co.1207	Co.1062	Means	LSD at 5 per cent level
Defoliated on 16th September	1.9 (7.5)	0.2 (2.0)	(4.8)	
Defoliated on 24th September	1.6 (6.8)	0.3 (2.7)	(4.8)	
Control	25.7 (30.3)	27.6 (31.7)	(31.0)	
Means	(14.8)	(12.1)	-	(2.5)
LSD at 5 per cent level			(2.9)	

* Figures in brackets represent data transformed by $\sin^{-1}\sqrt{\text{per cent flowering}}$.

Split-plot design; main plots to varieties; sub-plots to dates of defoliation; 5 replications; plot size 0.012 hectare.

The results (table 48) confirm that in these two varieties, flowering can be successfully prevented by defoliating the stalks in the 3rd week of September. The critical period was found to be same as that observed in last year's experiment.

Table 49

Cane yield and juice-quality of Co.1207 and Co.1062 as influenced by flowering and defoliation

Treatments	Co.1207*	Co.1062			
	Cane yield in metric tons per hectare	Cane yield in metric tons per hectare	Brix	Pol per cent juice	Purity
Defoliated on 16th September	63.85	56.85	18.1	15.41	85.3
Defoliated on 24th September	61.95	52.75	ND	ND	ND
Control	51.11	57.15	17.4	14.57	86.3
LSD at 5 per cent level	Not sig.	Not sig.	0.4	Not sig.	Not sig.

* In the case of Co.1207; juice analysis was not carried out as the cane lodged heavily; ND: not determined.

Differences in cane yield between control and defoliated plots in neither of the varieties were statistically significant. The juice-quality was better in the non-flowered defoliated stalks in the case of Co.1062, but the difference in pol per cent juice was not statistically significant (R.R. Panje, T. Raja Rao and K.K. Srivastava).

ii) Effect of defoliation on the flowering of different varieties .- In order to ascertain whether the critical period and the extent of defoliation required for the suppression of flowering are the same in all varieties, an experiment was conducted with 6 varieties viz., Co.205, Co.1062, Co.1089, Co.1207, Co.1171 and Co.1055. Two levels of defoliation, namely i) removal of the spindle cluster together with the blade of the top-most dewlap, and ii) removal of spindle cluster and three more blades below it,,were compared against an undefoliated control. The defoliation dates were 7 in number, starting from the 4th week of August and were at weekly intervals upto the 1st week of October (table 50).

Table 50

Percentage of flowering and short-blade stalks at harvest in the different varieties as influenced by dates of defoliation

Defoliated on		Co.205	Co.1207	Co.1062	Co.1055	Co.1089	Co.1171
August 25th	A*	18.2	22.3	24.3	18.8	12.6	40.6
	B*	5.7	12.6	11.0	7.0	9.8	24.4
September 1st	A	10.4	13.7	11.4	4.2	11.2	23.2
	B	0.5	14.0	4.0	1.8	2.7	26.9
" 8th	A	2.6	3.0	0.0	0.7	0.8	11.1
	B	2.1	5.4	0.5	0.2	2.6	15.4
" 15th	A	3.3	1.6	0.1	0.0	6.1	4.9
	B	5.1	1.3	0.3	1.5	3.4	4.4
" 22nd	A	4.5	6.7	0.4	1.1	3.8	5.1
	B	0.7	3.9	1.8	0.5	2.1	1.1
" 29th	A	11.8	4.7	0.0	1.8	10.5	12.4
	B	7.7	0.6	0.5	0.4	4.4	9.7
October 6th	A	39.0	16.2	5.3	5.9	11.1	33.8
	B	30.7	16.2	7.3	4.1	14.5	36.2
Control		46.8	38.8	39.6	33.8	35.2	55.6

* A - Spindle cluster removed
B - Spindle cluster and three leaves removed.
Split plot design, main plots to varieties, sub-plots to treatments and sub-sub plots to dates, 4 replications, plot size is two rows each of 7.6 meters length.

In all the 6 varieties, the treatments showed a clear, sharp and more or less uniform fall in the flowering percentage from end-August to about the middle of September when the maximum suppression occurred. This was followed by a rise in flowering percentage and this was, at about the same rate as the fall (fig.1 and 2).

The data were analysed statistically after inverse sin transformation. The overall mathematical curve for the flowering of these varieties was worked out: it is represented by the equation $y = 44.7 - 18.6x - 2.2x^2$, where y' represents the expected $\sin^{-1}\sqrt{\text{per cent value}}$

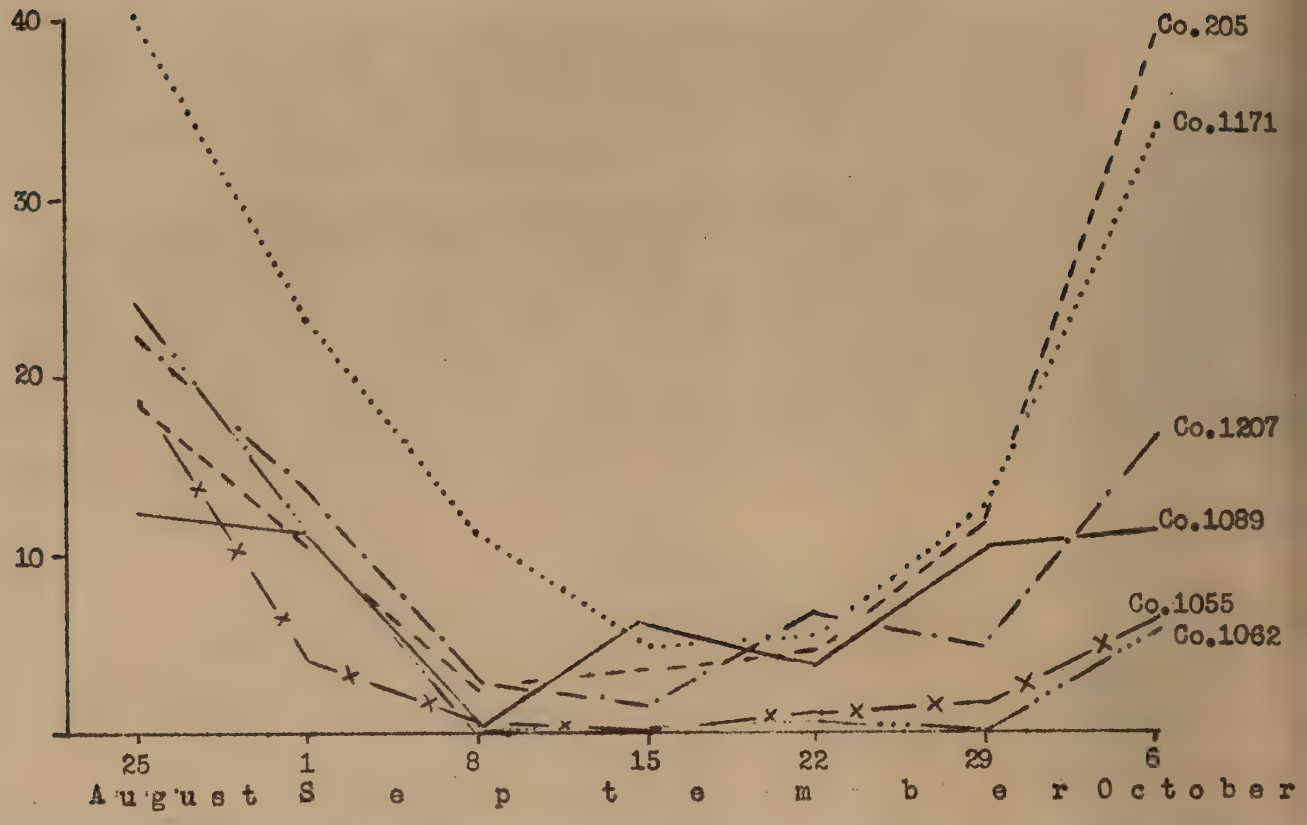


Fig.3 - Percentage of flowering in different varieties as influenced by dates of defoliation. Ordinates: Percentage of flowering. Abscissa: F Dates of defoliation.

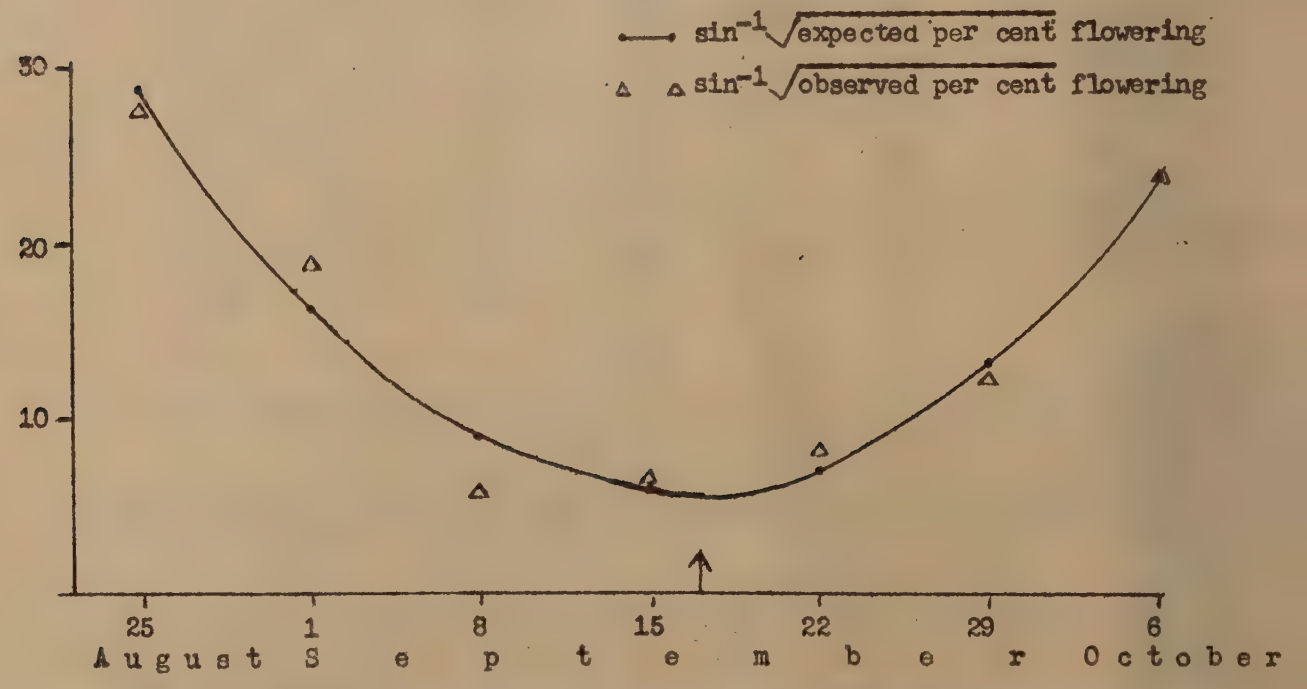


Fig.4 - Flowering in different varieties as influenced by dates of defoliation. Ordinates: $\sin^{-1}\sqrt{\text{per cent flowering}}$. Abscissa: Dates of defoliation.

and 'x' denotes the defoliation date. This empirical curve fits significantly with the observed percentages, giving the value of R = 0.981 and R^2 = 96 per cent.

The critical period was found to lie between 8th and 22nd September in the case of almost all the varieties tested. Although the defoliation is substantially effective in the whole month of September, the most effective period was over a period of 15 days starting from 8th September. The indication from the mathematical curve is that for maximum suppression the stalks have to be defoliated on 17th September.

The results indicate that spindle cluster together with the blade of the top-most dewlap constitute the principal organ for the perception of photo-periodic stimulus in all the varieties tested (R.R.Panje, T. Raja Rao and K.K. Srivastava).

iii) Effect of maleic hydrazide and naphthalene acetic acid on the flowering of Co.1207.- In this experiment two chemicals, maleic hydrazide and naphthalene acetic acid were employed, and there were three treatment dates of spraying for each, viz. 9th, 19th and 28th September. Both the chemicals were applied at 4.5 kg per hectare. A water-sprayed control was provided.

Table 51

Effect of maleic hydrazide and naphthalene acetic acid on the flowering of variety Co.1207*

Sprayed on	Control (water spray)	Maleic hydrazide @ 4.5 kg per hectare	N.A.A. @ 4.5 kg per hectare	Means	LSD at 5 per cent level
September 9th	55.5 (48.2)	41.3 (39.9)	39.2 (38.0)	(42.1)	
" 19th	53.5 (47.1)	44.2 (41.6)	55.4 (48.1)	(45.6)	
" 28th	39.9 (39.1)	43.7 (41.2)	45.2 (42.2)	(40.9)	
Means	(44.8)	(41.0)	(42.8)		Not sig.
LSD at 5 per cent level				Not sig.	

* Figures in brackets are the data transformed by $\sin^{-1}\sqrt{\text{per cent}}$. Split-plot design, main plots to dates of sprayings sub-plots to chemicals, plot size is two rows each of 6.1 meters length, 4 replications.

The data given in table 51 indicate that the percentage of flowering was not significantly affected by spraying either maleic hydrazide or naphthalene acetic acid on the crop on any of the three dates (R.R. Panje, T. Raja Rao and K.K. Srivastava).

iv) Effect of cobaltous nitrate on the flowering of Co.1207.- The objective of this experiment was to lower the rate of oxidation of the native indole-acetic acid in the plant during the critical photoperiod and to study the influence of this reduction on the flowering propensity. As the cobalt-ion can lower the activity of I.A.A.-oxidase through its depressing effect on the peroxigenesis, cobaltous nitrate was employed in this study. The experiment was laid out with Co.1207, with six treatments (table 52).

The data in table 52 indicate that cobaltous nitrate inhibited flowering in the crop significantly when sprayed at 2.25 kg per hectare

Table 52

Effect of cobaltous nitrate on the flowering of Co.1207

	Control (water spray)	Sprayed on 16th Sept. 2.25 kg per hectare	Sprayed on 16th Sept. 4.5 kg per hectare	Sprayed on 24th Sept. 2.25 kg per hectare	Sprayed on 24th Sept. 4.5 kg per hectare	Sprayed on every third day from 16th Sept. to 7th Oct. 9 kg per hectare @ 1.125 kg per hectare at a time	LSD at 5 per cent level
Observed percentage of flowering	50.0	25.5	44.8	42.5	35.5	26.0	
Data transformed by Sin-1 √per cent	45.3	29.8	43.9	40.6	36.4	30.6	9.7

Four randomised blocks; plot size is two rows each of 6.1 meters length.

on 16th September, and also when sprayed eight times from 16th September to 7th October at 1.125 kg per hectare each time. The reason for the lack of inhibition when the chemical was sprayed at 4.45 kg per hectare on 16th September needs further investigation (R.R. Panje, T. Raja Rao and K.K. Srivastava).

2. Studies on germination

i) Effect of preventing loss of moisture from the setts on germination.- The experiments conducted last year had shown that fresh setts possess moisture in sufficient amounts to enable their buds to germinate when this moisture is conserved. In continuation of these studies, this year it was ascertained whether setts which had lost an appreciable amount of their initially-contained moisture would be able to germinate if further losses of moisture from them are prevented; i.e. how far germination is affected by the lower moisture status of the sett.

Single-budded setts of variety Co.453 were cut and allowed to lose their moisture for 0, 3, 6 and 9 days; at the end of the period, they were coated with bees-wax and kept without any cover in the laboratory. For comparison, one batch of fresh setts not coated with wax were also kept by the side of the above. In each treatment, 25 setts were used. The initial moisture per cent of the setts was assessed roughly by taking samples from the two cut-ends of each sett.

Table 53

Effect of preventing loss of moisture from the setts on the germination and growth of buds

Setts dried for	Mean initial moisture per cent fresh weight in end portions of the sett	Mean percentage loss in weight of setts during dryage: Observed	Mean percentage loss in weight of setts during dryage: Date transformed by $\sin^{-1}\sqrt{\text{per cent}}$	Percentage of germination after 18 days	Average height of the shoots in cm after 18 days
Wax-coated					
0 days	73.9	-	-	100	5.2
3 days	72.3	8.8	17.3	68	0.9
6 days	72.2	12.1	20.3	80	1.5
9 days	73.9	19.1	25.9	80	1.1
Not wax-coated					
0 day	73.5	No germination			
LSD at 1 per cent level	Not sig.	-	2.5	-	2.3

The losses in the weight of the setts in the different treatments were much higher than could be accounted to respiration, and it can be reasonably assumed that the major factor contributing to the loss in weight of the setts was the loss of moisture.

While the uncoated setts did not germinate in all the wax-coated treatments germinations started within 18 days (table 53). Even the setts which were allowed to lose their moisture for 9 days and then wax-coated, about 80 per cent were able to germinate. The difference really was in height of the shoots formed, which was significantly lower in the setts which were allowed to lose their moisture in comparison with those of the fresh setts. This is quite in keeping with expectations since bud-germination itself is a phenomenon of elongation and growth, and in planted setts, failure of elongation is a failure of germination.

These results indicate that setts possess adequate amounts of moisture for the functioning of the buds and that the buds can germinate without root activity after losing as much as about 20 per cent of the water contained in them, provided a further drawal of moisture from the sett is prevented (R.R. Panje and T. Raja Rao).

ii) Effect of increasing the moisture content of setts on germination.- As against the effect of losses of moisture observed in the previous experiment, the effect of providing additional moisture to setts on bud germination and root development was elucidated in the following three experiments.

Experiment (a) - Twenty single-budded setts of variety Co.453 were cut from 10 canes and divided into two batches of ten each. One batch of setts was soaked in distilled water for one hour and the other was used as control. The weighment of the setts individually before and after the soaking treatment showed that setts gained about 0.5 g to 1.0 g of water in the soaking treatment. The setts were kept in chambers in which the atmosphere was saturated with water vapour.

Table 54

Effect of soaking setts in water on shoot growth and root development

Treatment	Percentage of germination on 7th day	Average height of the shoot in cm on 7th day	Average number of roots per sett on 7th day	Average dry weight of roots per sett in mg on 7th day
Setts soaked in water	100	3.5	29	47.2
Control	90	1.3	18	15.6
LSD at 1 per cent level	-	1.2	9	14.9

Soaking of setts in water not only improved the germination and growth of the shoot (table 54) but markedly increased root production. The mean dry weight of the roots per soaked sett was over three times as much as that of fresh setts.

Experiment (b) - The second experiment was carried out to find out whether the improvement in the shoot and root development observed in soaked setts in the above experiment is due to any wetting action on buds or the removal of any noxious substances from the sett during the soaking treatment, or is a direct effect of the water taken up by the sett. Fifty single-budded setts of variety Co.453 cut from 25 canes were made into

two batches of 25 setts each. In each of the setts of one batch, two small holes of 0.5 cm diameter and about 1 cm depth were drilled radially on the internodes, one near each cut-end, and about 0.4 cc of distilled water was poured into each hole; the holes were then sealed off. Both batches of setts were placed in chambers with an atmosphere saturated with water vapour.

Table 55

Effect of addition of water to setts on shoots and root development

Treatment	Percentage of germination on 7th day	Average height of the shoot in cm on 7th day	Average number of roots per sett on 7 day	Average dry weight of roots in mg per sett on 7th day
Setts to which water was added in holes drilled on end-internodes	93	1.7	21	46.3
Control	100	1.5	19	17.2
LSD at 1 per cent level	-	Not sig.	Not sig.	9.4

Data collected on the 7th day (table 55) showed that although the growth of the shoot in the treated setts was not significantly more and the number of roots sprouted was also about equal in the treatment and control, the growth and development of the roots was more than twice as much as that of fresh setts, the difference being significant at 1 per cent level.

Experiment (c) - In the third experiment, the two water-addition treatments were directly compared for purposes of confirmation of the above observations. Twenty single-budded setts were used in each treatment. The method of application of the treatments was the same as described in the two preceding experiments.

Table 56

Effect of increasing the moisture content of setts on shoot growth and root development

Treatment	Percentage of germination on 7th day	Average height of the shoot in cm on 7th day	Average number of roots per sett on 4th day	Average number of roots per sett on 7th day	Average dry weight of roots in mg per sett on 7th day
Setts soaked in water	100	2.0	3	7	13.3
Setts to which water was added in holes drilled on internodes	95	1.9	7	11	23.0
Control	95	1.6	1	3	3.4
LSD at 5 per cent level	-	0.34	3	5	11.5
LSD at 1 per cent level	-	Not sig.	4	6	15.4

No significant differences were observed between the treatments in respect of germination percentage or height of shoot at 1 per cent level, but root production was significantly more in setts in which the moisture content was increased by the addition of water in holes drilled on internodes. The manner of increasing the water in the sett did not make significant difference.

These experiments have shown that enhancement of moisture of setts accelerates root production. They also suggest that the improvement in germination brought about by soaking is due to the direct influence of the water taken up by the setts rather than to the contact of the bud and root primordia with water or the removal of any harmful substances from the setts (R.R. Panje and T. Raja Rao).

iii) The influence of bud on the growth of root primordia.- In order to ascertain whether the bud has any influence on the sprouting and growth of root primordia of the sett, an experiment was carried out using setts in which the buds were removed against normal setts with buds. The experiment was conducted three times, in November, January and April, using single-budded setts of variety Co.453. The number of setts used per treatment were 19, 36 and 50 in the three successive experiments.

Table 57

Effect of removal of buds on the rooting of setts of variety Co.453

Treatment	Average number of roots per sett		
	November experiment (as on 16th day)	January experiment (as on 15th day)	April experiment (as on 8th day)
Setts with buds removed	29	15	25
Setts with buds intact	19	5	15
LSD at 1 per cent level	6	5	4

The results of all the three experiments (table 57) have shown that in the setts in which the buds were removed, a larger number of root primordia sprouted and developed into roots than in the normal setts. This indicates that under certain conditions the bud has some influence on the growth of the root primordia (R.R. Panje and T. Raja Rao).

iv) The effect of relative humidity of the surrounding atmosphere on the germination of buds.- With a view to knowing the influence of the relative humidity of the surrounding atmosphere on bud germination and root growth, two experiments were conducted.

(A) Sixty single-budded setts of variety Co.453 were taken from 30 canes and were divided into two equal batches. One batch was kept at 85 per cent relative humidity while the other was kept at 96 per cent relative humidity. In both cases the temperature was 31°C. The observations as recorded on the 6th day are given in table 58.

The experiment has clearly shown that while germination of buds is not affected by the slightly lower degree of relative humidity, the rooting is markedly influenced. Setts kept at 96 per cent relative humidity rooted fairly freely, whereas none of the setts kept at 85 per cent relative humidity put out any roots. The growth of the shoot was distinctly less at 85 RH than at 96 RH.

Table 58

Effect of relative humidity of the surrounding atmosphere on the shoot and root development of single-budded setts of variety Co.453

Treatment	Percentage of setts germinated	Percentage of setts rooted	Average number of roots per sett	Average height of shoot in cm
Setts kept at 85 per cent RH	90	0	0	1.0
Setts kept at 96 per cent RH	100	100	13	4.0
LSD at 1 per cent level	-	-	-	0.8

(B) In order to ascertain whether the root-primordia of the setts are permanently damaged when kept at 85 per cent relative humidity, 35 single-budded setts of variety of Co.453 were kept at 85 per cent relative humidity for 14 days and then transferred to 96 per cent relative humidity at which they were kept for another 14 days; observations were made at the two stages.

Table 59

Effect of relative humidity of the surrounding atmosphere on the shoot and root development of single-budded setts of variety Co.453

Treatment	Percentage of germination	Percentage of setts rooted	Average number of roots per sett	Average height of the shoot in cm
Setts kept at 85 per cent RH at 31°C for 14 days	100	0	0	3.2
After transfer to 96 per cent RH at 20°C for 14 days	100	77	5	6.2

The experimental data in table 59 confirm the results obtained in the previous experiment. The setts which were unable to root when kept at 85 per cent relative humidity for 14 days were able to root when transferred to 96 per cent relative humidity. The buds were however, able to germinate at 85 per cent relative humidity (R.R. Panje and T. Raja Rao).

3. Biochemical basis of resistance to red rot in (in collaboration with the Mycology Section)

With a view to elucidating the amino acid constituents of the proteins of strains D and I, the fungal mats were hydrolysed with hydrochloric acid and chromatographically analysed. No qualitative differences were observed in the amino-acid composition of proteins among these two strains. The following amino-acids were found to be present in their proteins; aspartic acid, glutamic acid, glycine+serine, alanine, histidine, aminobutyric acid, valine and tyrosine (T. Raja Rao, Kishan Singh and T.R. Budhraja).

AGRICULTURAL ENGINEERING

(R.G. Menon : Agricultural Engineer)

1. Study and improvement of agricultural implements at present used for sugarcane cultivation in different regions

IISR Bullock-drawn Furrower.- In the north Indian sugarcane belt, furrows for planting sugarcane are usually opened out in two stages (i) opening out a shallow furrow with a desi plough and (ii) widening and deepening this furrow with a second desi plough in which the wedge had been widened either with planks nailed to the sides or with pieces of wood or sugarcane setts tied round the wedge. The furrows thus made are fairly clean and well formed. The implements manufactured in India and marketed as bullock-drawn ridgers are almost without an exception double mould-board ploughs or "middle busters", primarily meant for breaking ridges rather than forming furrows for planting. The double mould-board plough consists essentially of a right-hand and a left-hand mould-board plough-bottom bolted together and therefore the implement turns two rectangular furrow slices, one to the right and one to the left. But since the soil in which it works is already tilled, it is loose soil that is turned up and not a clean slice as in the case of a mould-board plough. A part of this loose soil slides back into the furrow and in the final form, the section of the furrow is trapezoidal. The sides of this furrow are composed of loose soil and any disturbance causes more soil to slide down from the crest. This may not be of much consequence in flat-planting where cane is planted shallow and the field is irrigated by flooding the whole field. But where it is desired to use the furrows subsequently for irrigation, and setts are to be laid fairly deep, it is necessary that the furrow walls should be sufficiently consolidated, so that the soil from the crest of the furrow does not slide down during the planting operations.

Keeping this in view, the design of a bullock-drawn furrow openers capable of opening a furrow about 15 cm deep using only one pair of bullocks was taken up. Several proto-types modelled on the standard tractor-drawn ridger bodies were fabricated and tested with varying degrees of success. The last model made was satisfactory in most respects, but the draft was found to be still a little beyond the capacity of one pair of bullocks. Further modifications aimed at reducing the draft are on hand (R.G. Menon).

2. Designing and fabricating improved bullock-drawn and tractor-drawn implements and other machinery for sugarcane cultivation

i) IISR Sugarcane Stripper .- In the usual way of detrashing sugarcane, the harvested stalks are picked up one by one and the green top is broken off by hand for use as fodder. The dry leaves and leaf-sheaths are then detached by means of a sickle (hasia). In doing so, the stalk is rotated and the cane is scraped all round with the sickle to remove its trash. To simplify and speed up this work, a new device called the IISR Sugarcane Stripper has been evolved. This device consists essentially of a pair of tongs, the jaws of which close to form a square and then extend beyond the square to form a 'V' in front. One of the two limbs is bent down and provided with a convenient wooden grip. A light tension spring holds the jaws closed. In cross section, the jaws are wedge-shaped. However, the edges are not sharpened; the Stripper works not by cutting through the leaf-sheaths, but by separating them and pushing them away from stalk. For stripping a cane stalk, the implement is held by its handle and the 'V' of the jaws is just pushed against the cane immediately above the topmost dry leaf-sheath. The cane stalk gets held lightly in the square between the jaws. The tool is then swept down the cane lightly but quickly, either in one swing or in 2 or 3 short strokes, without taking off the loose grip of the jaws on the cane and keeping the limb of the implement roughly at right angles to the cane all along. The tilted position in which the handle is fixed makes this work very easy. As the stripper is thus swept down the stalk, the jaws slide

in-between the successive leaf-sheaths and the cane, and being wedge-shaped they force the sheaths out from the cane; the sheaths, so pushed out, break away and fall off with almost no effort. The jaws make a light 4-point contact with the cane : This ensures that no sheath escapes the action of the wedges. The entire stripping is done in one pass of the instrument without turning the cane round and round.

Tests conducted have shown that stripping cane with IISR Stripper is about twice as fast as that in the conventional manner with a sickle.

The instrument is forged from 15 mm diameter mild steel round and the jaws are surface hardened. This stripper is estimated to cost about Rs. 6 each (R.G. Menon).

ii) Tractor-drawn Applicator for applying chemicals in the soil.- The design of an attachment suitable for the application of soil fumigants, liquid insecticides, liquid fertilisers and the like, in predetermined quantities and at predetermined depths in the soil was taken up. The preliminary design was for a gravity-feed single row applicator. This design consisted of a single cultivator tine fixed to a hydraulically-mounted tool-bar of a tractor and capable of penetrating the soil to a depth of about 18 cm to 22 cm. The chemical was fed from a tank mounted on the frame of the implement through a flexible pipe clipped to the back of the shank of the tine and discharging at its lower end. Two shroud plates were welded on to either side of the tine to ensure that the discharge opening of the pipe was not clogged with soil. The regulation of the quantity of liquid applied was by means of a faucet. The following observations were made during the trials conducted.

(a) A purely gravity feed was satisfactory where the rate of application of liquid was large; but it was not satisfactory for doses of the order of 4 or 5 lit per acre as in the case of soil fumigants since the latitude for variation in these cases was small.

(b) It was necessary to have the rate of feed related to the ground speed of the tractor.

Modification of the design incorporating a ground-speed controlled force-feed mechanism is now on hand (R.G. Menon and Kishan Singh).

3. Devising ways and means for conserving irrigation water

Experiments of the previous year with polyethylene layflat tubes for conveying irrigation water were continued, substituting black film tubes for transparent film. These tubes were laid out early in May and were in position and in use until the end of July. Practically trouble-free service was obtained throughout the period. These durability tests will continue for 3 years in the first instance (R.R. Panje and R.G. Menon).

4. Exploring possibilities of overhead irrigation of sugarcane

The experiment had to be abandoned due to mechanical failure of the overhead irrigation equipment (R.G. Menon).

5. Studies on important cultural operations in relation to crop yields and soil condition

The cost of preparatory cultivation in north India accounts for about 25 per cent of the total cost of sugarcane production. Presumably the purpose of preparatory tillage is only to provide an easy medium in which the young plants can spread their roots and function. Since cane is planted in rows about 90 cm apart and during the first

3-4 months upto the monsoon the plants made very little growth, presumably the extensive preparation of the soil serves very little actual use by the plant. On the other hand this tilling and the spread of irrigation water into the inter-spaces would encourage the development of lateral roots rather than the deep vertical roots which are vital to the plant during the drought period, and also promote the development of weeds.

Table 60

Details of tillage operation and irrigational and manurial schedules

Date	Conventional Tillage Operation	Strip Tillage Operation
A - Preparatory Cultivation		
10th Feb.	Ploughing to 20 cm depth	-
15th Feb.	Discing followed by a planking	-
18th Feb.	-do-	-
20th Feb.	-	-
23rd Feb.	-	Ripping to a depth of 30 cm
23rd Feb.	-	Rotavating to a depth of 20 cm
24th Feb.	Discing and planking	-
B - Planting		
25th Feb.	Planting	Planting
C - Irrigation and weeding		
7th Mar.	1st irrigation	1st irrigation
12th Mar.	1st hoeing and weeding	-
23rd Mar.	2nd irrigation	2nd irrigation
27th Mar.	2nd hoeing and weeding	-
15th Apr.	3rd irrigation	3rd irrigation
20th Apr.	3rd hoeing and weeding	-
17th May	4th irrigation	4th irrigation
21st May	4th hoeing and	-
26th May	5th irrigation	5th irrigation
31st May	5th hoeing and weeding	-
D - Manuring		
23rd Mar.	Top dressing of blood meal @ 25 kg nitrogen per hectare	Top dressing of blood meal @ 25 kg nitrogen per hectare
16th Apr.	Ammonium sulphate @ 50 kg nitrogen per hectare	Ammonium sulphate @ 50 kg nitrogen per hectare
31st May	-do-	-do-

It was thought that the tillage requirements of the sugarcane crop would be fully met if a narrow strip along the row where cane setts are actually planted is tilled to a depths of about 20 cm. If the soil in the interspaces is left untilled, it may reduce the tendency of roots to develop laterally and if the irrigation also is limited to the tilled and planted strips, it may retard the movement of moisture from the tilled strips into the inter-row spaces. In consequence, the spread of lateral roots into the interspaces would be further retarded.

In addition to the tilling of the strip, if the untilled soil below the strip is ripped to a depth of 30 cm or more, it would perhaps facilitate the development of vertical roots and the movement of irrigation water downwards.

By this technique, irrigation water could be applied where it is best conserved and used, and root development could be encouraged only in that region of the soil to which water has been directed; thus the best soil and best moisture conditions are economised and provided exclusively to the plants in the rows and not to the weeds or the space which for several weeks after planting remains unused and exposed to evaporation and exploitation by weeds.

With a view to testing the above hypothesis, an experiment was laid out with four treatments, combining two methods of tillage, (1) conventional tillage, and (2) strip tilling; with two methods of planting, (a) flat planting and (b) planting in deep furrows. The field was one which had been left fallow and untilled after the harvest of maize in early October 1960. Because of the ripping to be done as a part of the treatments, the experiment had to be carried out in the category mechanization experiments.

Details of the four treatments were :

(1) Conventional tillage.- The plots were ploughed once to a depth of 20 cm with a tractor-mounted mould-board plough and subsequently disced four times with a tractor-drawn off-set disc harrow. Each discing was followed by a planking. The operations were done uniformly over the whole field.

(2) Strip tilling.- In this, lines 90 cm apart were first marked out on the fallow field, and the soil was ripped to a depth of 30 cm along these lines with a tractor-mounted single-tyned cultivator. A narrow strip 20 cm wide was then rotovated along the ripped lines to a depth of 20 cm using a small rotary tiller powered by a 158 c c petrol engine.

(a) Flat planting.- Cane was planted at a depth of 10 cm in rows 90 cm apart using the IISR Bullock-drawn Sugarcane Planter.

(b) Furrow planting.- Furrows 15 cm deep and 90 cm apart were opened using a tractor-mounted ridging attachment. Cane was planted in these furrows and covered with a 5 cm layer of soil.

Details of the cultural operations etc. given to the crop are given in table 60. It will be seen that as against 9 cultivation operations spread over a period of 4 weeks as required in the conventional seed bed preparation, strip tilling consisted of only 2 operations which could be completed in one day.

The crop was planted on 25th February 1961; germination started about the 3rd week of March and was completed by the middle of April in all the plots. The final percentage germination was about the same in all the treatments, the shoots emerging slightly earlier in the furrow-planted crops obviously because of the thinner soil cover over the setts in these cases. Tillering was satisfactory in all the treatments, and at the end of June, there was practically no difference in the total numbers of shoots in the different treatments.

During the hot weather, all plots were given 5 irrigations, the flat planted ones being inundated as per prevalent practice while in the others water was let only into the furrows. In the latter the quantity of water used per irrigation was less than in the case of flood-irrigation.

Between planting time and the end of June, the plots under conventional tillage were hoed and weeded 5 times; strip-tilled plots on the other hand were not weeded at all, because the intention was to leave the inter-row spaces undisturbed as far as possible. However, weed growth in the strip-tilled furrow planted plots was so little that a weeding operation did not become very necessary. Even in the strip-tilled,

flat-planted plots weed growth was considerably less than in the conventionally tilled plots.

The development of the root system of plants in the four treatments was studied early in June before the break of monsoon, and again towards the end of the monsoon in mid-September. It was observed that during the dry summer months, when the crop was dependent almost entirely on irrigation, the plants in the strip-tilled plots had sent down a larger number of roots to the deeper layers of the soil than plants in the conventionally tilled plots. But during the monsoon, when the soil was more or less saturated with moisture, the plants in the strip-tilled plots developed lateral roots also. By that time plants in the conventionally tilled plots also developed vertical roots. Thus by the end of the monsoon, there was no noticeable difference in root spread between the 4 treatments.

At harvest there were no significant differences either in the number of millable canes or the yields per hectare between the different treatments (table 61)(R.G. Menon).

Table 61

Yield of cane in metric tons per hectare

Treatment	Flat planting	Furrow planting	Mean
Conventional tillage	47.24	49.20	48.22
Strip tillage	50.00	49.93	49.96
Mean	48.62	49.56	49.09
SE for tillage and planting method	± 1.806		

2 x 2 Split plot design, with main plots to tillage methods and sub-plots to planting methods; 4 replications; Co.1158; planted 25th February 1961.

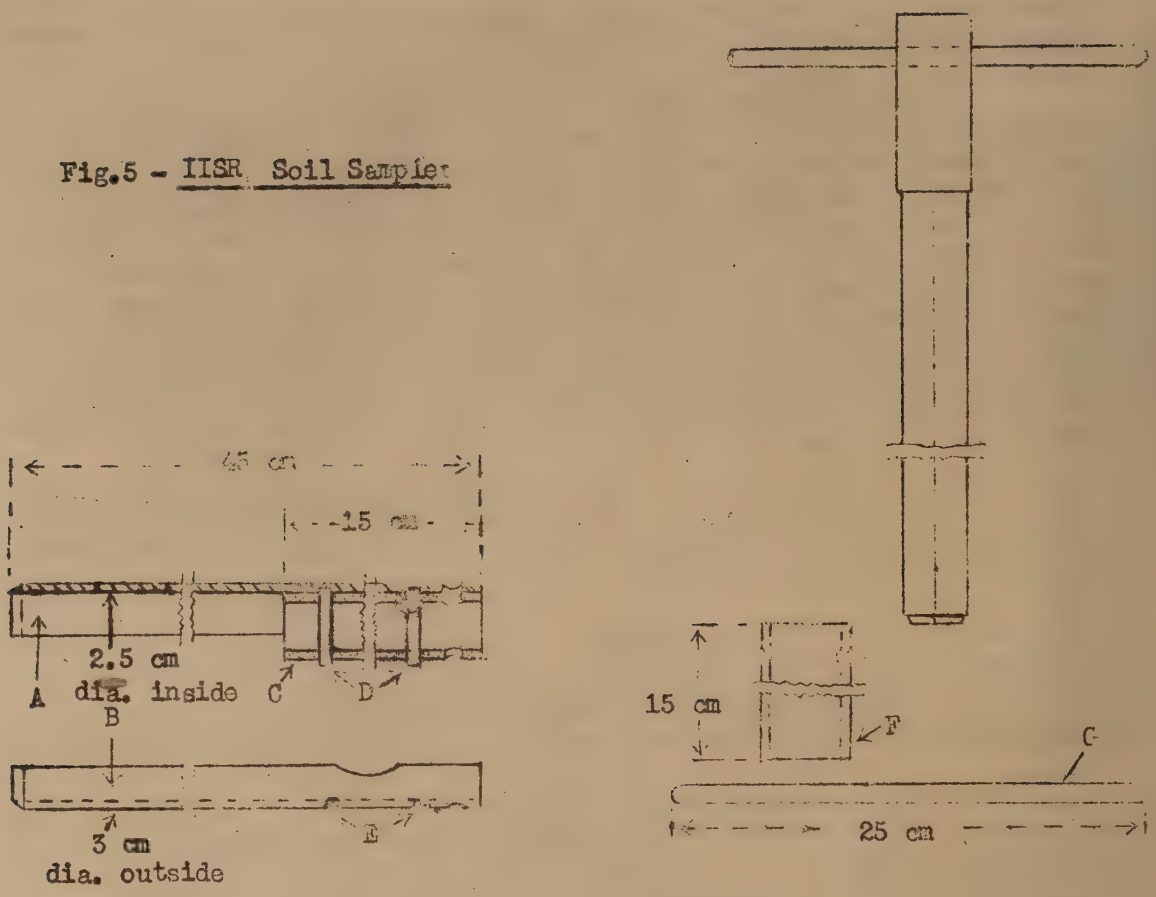
6. Miscellaneous

i) The IISR Soil Sampler .- Samplers used for drawing soil samples in agricultural research are mainly of two types: (1) the auger type and (2) the core type. The auger type is generally employed where it is neither necessary to obtain an "undisturbed" and uniform sample, nor a sample exclusively from a specified layer unmixed with soil from other layers. The core type on the other hand cuts out a cylindrical core of "undisturbed" soil from which it is possible to isolate portions belonging to different layers.

The usual type of the core sampler consists of a pipe ground to an edge at one end and provided with a tommy bar handle at the other end. In this type, the core of soil sample collected by the implement has to be gently drifted or pushed out from inside the pipe with a rod inserted from the top end. This process of removing the sample is far from easy especially where the soil sampled is moist and clayey. Further in the process of forcing the sample out, the core often suffers damage and it becomes difficult to isolate portions from the different layers. With core thus damaged, it cannot be said that the sample obtained is truly undisturbed.

A modified core-type soil sampler was designed at the Institute. This sampler (fig.1) consists of a thin-walled steel tube 2.5 cm in diameter and about 45 cm long split into two halves A and B along its length.

Fig.5 - IISR Soil Sampler



A short piece of pipe C about 15 cm long, and fitting exactly into the bore of the sampler tube is brazed on to the inside at the top end of one of the halves A. The other half B is then held in alignment by 2 dowel pins D,D, engaging in corresponding holes E,E, in the half B. The two halves are held together in position by a sleeve F slipped over the tube assembly. A tommy bar G going through the sleeve and the tube assembly provides a convenient handle. The lower end of the tube assembly is ground to an edge and hardened. The entire sampler is heavily chromium-plated to reduce friction between the soil and the tube walls and a possible distortion of the core.

To draw a sample of soil, the sampler is driven down into the soil to the desired depth and then pulled out in much the same way as the conventional core sampler. To remove the core, the sampler is laid flat on the ground with the half A below and the half B above; the tommy bar and sleeve are removed and the upper half A of the sampling tube is taken off. The core of soil can now be easily and neatly removed and the different layers can be cut away and separated if desired (R.G. Menon and Kishan Singh).

ii) Gur Hardness Tester.- An apparatus for the determination of the hardness of gur ssamples in the laboratory was designed and fabricated. This instrument consists of a vertical brass tube 'A' (fig 7) approximately 2.5 cm in diameter and exactly 53 cm in height. This tube is provided with two horizontal cross arms 'BB' in the middle of its length, carrying at their free ends two guide bushes 'CC' whose axes are parallel to that of tube 'A'. The guide bushes slide on two vertical cylindrical guides 'DD' fixed to a base plate 'E'. A needle 'F' 2.5 mm in diameter and 2.5 mm long is fixed to the bottom of a cylindrical weight 'G' capable of sliding freely inside tube 'A'. The combined length of the weight and needle is 6 cm. The needle and the cylindrical weight are co-axial and together weigh exactly 100 g. The needle itself 2.5 mm in diameter has a conical head 4 mm in diameter, with an apex angle of 60°. The weight with its needle are held

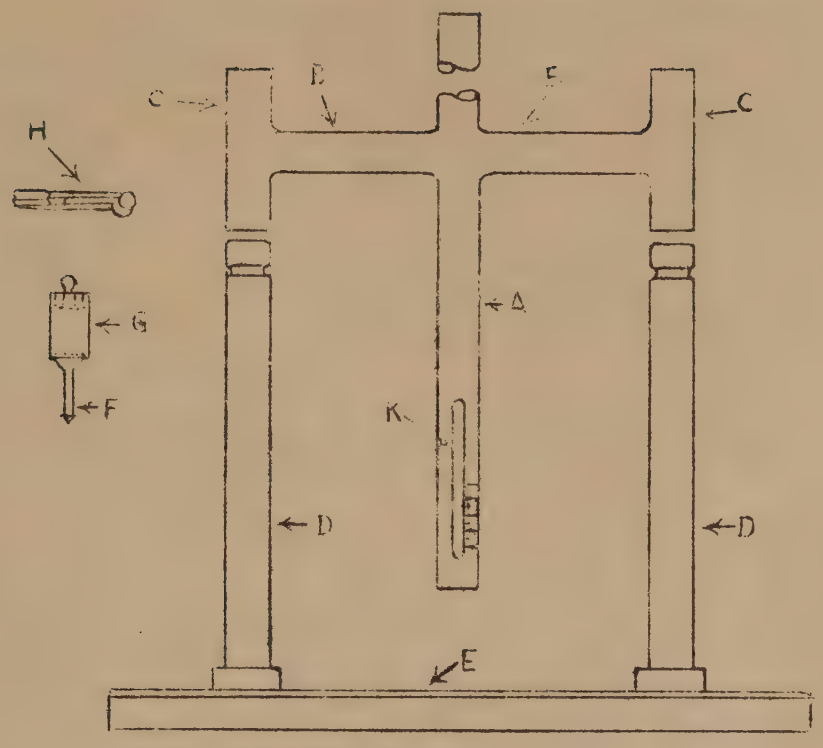


Fig.6 - IISR Gur Hardness Tester

in position inside tube 'A' with the top of the weight exactly on a level with the top of the tube by means of a spring clip 'H'.

To measure the hardness of a sample of gur, the tube 'A' is raised and the sample is placed on the base plate. The tube is then lowered to rest on the top of the sample. The weight is released from the top of the tube 'A' by pressing the spring clip, and allowed to fall freely on to the sample. The height of the brass tube and the length and weight of needle are such that the needle drops exactly through a distance of 50 cm when released. The depth to which the of the needle penetrates into the sample is measured in centimetres on graduations along the edge of an observation slit 'K' in tube 'A'.

The instrument was designed to the specifications of the Gur Chemist and is being tested by him (R.G. Menon and A.S. Sastry).

iii) A design for a godown for drying and storing gur under north Indian conditions.- Investigations carried out in the Gur Storage Scheme at this Institute have shown that one of the important factors that determine the keeping quality of gur is its own moisture content, composition and quality. Among the external factors the most important are the conditions of humidity and temperature under which gur is stored. Experiments in the Gur Storage Scheme have indicated that gur having an initial moisture content not exceeding 8 per cent can withstand humidities upto 58 per cent without any appreciable deterioration even when temperatures rise to 40°C. It was therefore inferred that if the moisture in all the gur to be stored is first reduced to 8 per cent or less, and the godown is thereafter sealed against ingress of moisture from the floor, the walls and the ceiling, and is also provided with a certain amount of thermal insulation to keep down the variations of temperature, it should be possible to carry the stored gur through the monsoon in a satisfactory condition. The intention was to utilise the dry atmospheric conditions which prevail for about 3 months, March to May, for drying of the gur to the required level, and to modify the constructional details to prevent ingress of moisture and ensure insulation.

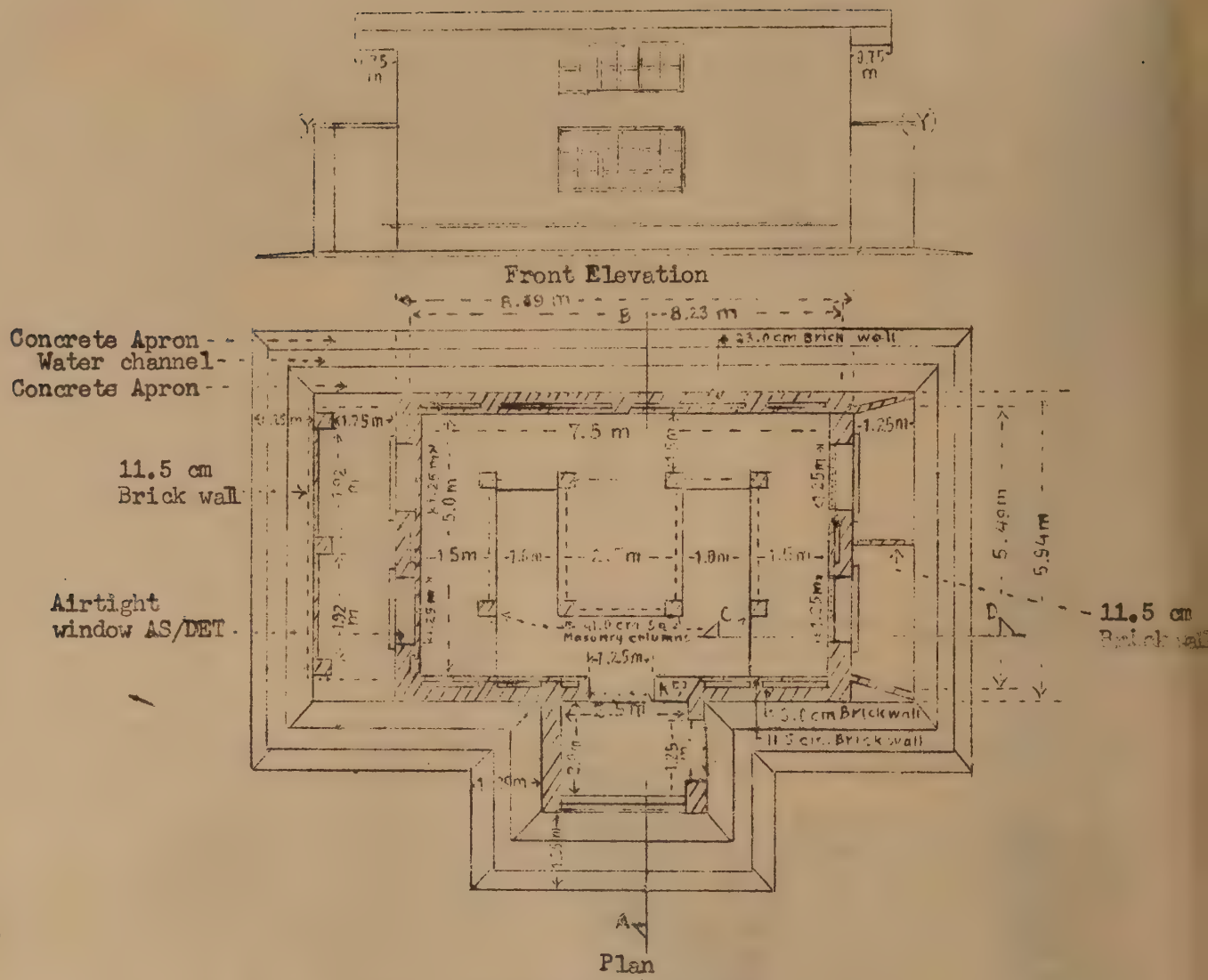


Fig.7 - IISR Gur Storage Godown

A gur storage godown to meet these requirements was designed during the year. This design aims at admitting the dry air into the godown during the dry season and ensuring a high degree of sealing of the interior against ingress of moisture in the monsoon and providing a fair amount of thermal insulation by using air itself for the purpose. The basic unit designed is capable of storing 50 metric tons of gur, the smallest economic size. The storage capacity can, however, be increased by duplicating the unit either along its length or width, or quadruplicating by both means, and eliminating the middle walls.

The basic unit (fig.7) consists of a room closed by 4 cavity-type walls of brick masonary. The thermal insulation is provided by the air space between the inner and outer walls. The roof is also double and consists of an A.C.C. roof over a RCC slab with an air space in between. This roof is laid with a slope of 1 in 15 for rapid drainage of rain water. Two tiers of RCC shelves are provided along the walls with a passage to permit easy handling of the stored material.

To prevent seepage of moisture, the floor is finished with a four-layer waterproof asphalt coat over cement concrete; the internal surfaces of walls, ceiling and shelves are also finished with a damp-proof asphalt course.

The entrance of the godown is through an ante-chamber. The door leading from the ante-chamber into the godown is bolted down against the surface of the walls when closed, and is made air-tight by a rubber seal on all four sides between the wood frame and the wall surface.

The dry conditions prevailing from March to May are availed of for desiccating the stored gur in the godown to the maximum extent possible by allowing the dry air to permeate freely into the godown. For this purpose four windows are provided, two on the eastern face and two on the western. For the protection of the stocks, iron grills are provided on the inside of the window openings. The windows have shutters opening outward and these are provided with bolts and rubber seals so that they can be closed airtight in the same way as the door shutter. The windows on the western face are enclosed in a box type louvre to further facilitate the channeling of dry air through the godown. To prevent the comparatively moisture easterly winds from blowing through the godown, a baffle is provided in front of the windows on the eastern face.

A special concrete drip provided at plinth level all round the building makes it rat-proof and a concrete water channel 30 cm wide on the apron all round the building keeps ants out.

The godown has to be located along the direction of the dry winds in the locality so that these winds can be admitted into the godown to the extent necessary through the louvred windows. Gur when received for storage is stacked on the shelves, the space in front of the window openings being left empty until the last, so as to ensure effective ventilation, as long as possible. A step ladder is to be used for loading the top shelves. The door between the ante-chamber and the godown is kept bolted in position at all times excepting when material has either to be taken into or taken out of the godown.

During the dry summer, the windows are left as open as necessary during all periods when both humidities and temperatures are low, so as to dry off the gur as much as possible. The windows should be closed whenever there are any sudden thunder showers and hailstorms during the hot weather or if at any time the humidity rises above 40, and the temperature beyond say, 40°C. When nights are dry the windows can be kept open at night also and closed at about 12 p.m. as this will keep the godown cool as well as dry. A large size thermo-hygrometer fixed on the front door outside will help to operate the godown efficiently.

As soon as the moist winds start blowing before the break of monsoon the windows are bolted down tight against the walls.

In removing gur from the godown during the monsoon, care has to be taken each time that both the doors of the ante-chamber are not left open at the same time. The windows should not be opened on any account until the weather becomes dry again. The water channel on the apron should be filled daily and should never be allowed to go dry.

The estimated cost of construction of a basic unit of the above design is about Rs.25,000. At 5 per cent interest and 5 per cent depreciation the annual maintenance cost on account of the building alone is Rs.1,500, or Rs.30 per metric ton. The cost will be still less when the godown is duplicated and capacity doubled or quadrupled (R.R. Panje and R.G. Menon).

MYCOLOGY

(Kishan Singh : Mycologist)

1. Red rot [*Glomerella tucumanensis*]

i) Standardisation of the technique of inoculation by plug method.- In the plug method of inoculation currently employed in red rot investigations, no control is usually maintained over the depth of cavity made in the stalk, the presence of spores in the inoculum, and the amount of inoculum deposited. During the year, some improvements over the existing technique were effected in order to reduce the variation in lesion length. The use of the IISR inoculator for making a clean cavity of small size and uniform depth has been already reported (IISR Ann. Rep. 1959-60, p.61). Since spores travelling through xylem vessels may hasten the spread of linear infection in individual cases, inoculations were effected with inoculum homogenised in a blender. The quantity inoculated was regulated by injecting the inoculum through 25 ml Roux syringe suitably adjusted to deliver equal quantities.

For increasing the speed of work and reducing the cost, instead of tying up the site of inoculation with a strip of waxed or greased paper held in place by a piece of string, plasticine was used this year to close up the cavity. This proved quite satisfactory and efficient (Kishan Singh).

Table 62

Varieties classified on the basis of observed reaction to red rot infection by plug method

Lesion per cent stalk length	Varieties
0 - 10.0	Nil
10.1 - 20.0	Co.449, Co.969, Co.976, Co.1062, Co.1064, Co.1066, Co.1067, Co.1070, Co.1072, Co.1074, Co.1078, Co.1111, Co.1113, Co.1115, Co.1138, Co.1149, Co.1153, Co.1164, Co.1207, Co.1251, Co.1254, Co.K.32, B.O.3 and B.O.29.
20.1 - 30.0	Co.419, Co.453, Co.997, Co.1087, Co.1101, Co.1114, Co.1116, Co.1121, Co.1130, Co.1143, Co.1152, Co.1155, Co.1156, Co.1158, Co.1300, Co.1301, Co.1304, Co.1305, Co.1306, Co.1307, Co.1308, Co.1322, Co.1325, Co.1326, Co.S.245, B.O.4, B.O.10, B.O.11, B.O.17 and B.O.24.
30.1 - 40.0	Co.313, Co.331, Co.1073, Co.1085, Co.1102, Co.1144, Co.1191, Co.1303, Co.1318, Co.1319, Co.1321, Co.1324, Co.S.443, B.O.9 and B.O.14.
40.1 - 50.0	Co.527, Co.617, Co.951, Co.963, Co.1071, Co.1075, Co.1076, Co.1112, Co.1317 and Co.S.510.
50.1 - 60.0	Co.213, Co.513, Co.1069, Co.1117, Co.1162, Co.1189 and Co.1320.
60.1 - 70.0	Co.1080, Co.1089, Co.1302 and B.O.15.
70.1 - 80.0	Co.1079.
80.1 - 90.0	Nil
90.1 -100.0	Co.312, Co.996 and Co.1063.

ii) Stalk resistance of varieties.- Fifty canes of each of 94 varieties were inoculated with profusely sporulating cultures of isolate D of C. falcatum in August, 1961 employing the IISR inoculator and the standardised inoculum technique. This year, the post inoculation period was limited to three months: all the same, marked differences between the varieties were noted. B.O.3 and Co.969 and Co.1164 came out as moderately resistant (table 62) (C.L. Subramanian and S.P. Dwivedi).

iii) Mechanism of disease resistance.-

(a) Differences among the isolates (linear spread method).- In the experiment conducted last year (IISR Ann. Rep. 1960-61, p.78), indications were obtained that the different isolates differed in their linear spread within inoculated stalks. The experiment was repeated with 28 isolates on 10 varieties (table 63). 20 apparently healthy stalks of each variety for each isolate were inoculated employing the standardised plug method, in September and harvested in the end of December, 1961. The linear spread of symptoms was recorded in each cane. The linear spread of symptoms on Co.622 caused by different isolates was analysed statistically; the differences among the isolates were very highly significant. Two main groups could be made out (table 63). Whether these isolates maintain their comparative reactions in subsequent seasons is under investigation. Differences among other varieties within each group were not so well marked (S.P. Dwivedi and Kishan Singh).

Table 63

Mean lesion length in stalks of Co.622 inoculated with isolates of red rot by standardised plug method

Isolates	Mean length in cm	Grouping with LSD at 0.1 per cent level
LR 24	136	
LR 13	130	
LR 12	120	
LR 16	117	
LR 15	114	
LR 19	67	
LR 22	49	
LR 23	47	
LR 4	42	
M	41	
A	40	
LR 11	37	
LR 6	37	
LR 5	35	
LR 9	34	
LR 10	31	
LR 7	30	
LR 17	28	
LR 14	27	
LR 8	25	
LR 3	23	
LR 18	22	
LR 1	19	
LR 20	17	
C	17	
LR 2	15	
B	15	
I	13	
SE	± 7.7	
LSD at 0.1 per cent level	35.8	

(b) Differences among the isolates (symptomatic method).- Varietal differences in reaction were also assessed by the symptomatic method of Srinivasan and Bhat (1961)*. As a set of standard hosts have not been worked out for the different physiologic races of C. falcatum as yet, the reactions were tested on ten varieties, inoculated and harvested as above. From each variety-isolate combination, the worst affected stalk was selected for recording the ratings. The criteria for selection were the condition of the tops, width of lesion, linear spread of symptoms, presence of serial spots, central core, nodal necrosis and the type of lesion with regard to its tendency to spread. On the basis of these characters, the host reactions were classified as moderately resistant (MR), moderately susceptible (MS), susceptible (S), and highly susceptible (HS). Resistant or highly resistant reactions were not observed in any case.

Table 64

Grading of varieties by symptomatic reaction of stalks against red rot isolates

Isolate	Stalks of varieties inoculated									
	Co. 312	Co. 385	Co. 419	Co. 453	Co. 527	Co. 622	Co. 951	Co. 997	Co.S. 443	Co.S. 510
LR-1	S	MS	MS	S	S	S	S	HS	S	HS
LR-2			MS			S	HS	MS	S	HS
LR-3		MS	S		S	S		HS	HS	HS
LR-4		MS	S			S	HS		HS	HS
LR-5		S	S	MS	S	S	HS	HS	HS	S
LR-6		S	MS	HS	MS	S	HS	S	HS	HS
LR-7			S	S	S		HS	S	HS	S
LR-8		S	S	HS	S	S	HS	S	HS	HS
LR-9	HS	S	S	HS	HS	MS	S	MS	HS	S
LR-10	S	S		HS	HS	S	S	MS	HS	HS
LR-11	HS	HS	S	HS	HS	HS	HS	S	HS	S
LR-12	S	HS	S		HS	HS	S	HS		HS
LR-13		HS	MS	S	S	HS	HS	HS	S	S
LR-14	HS	MR	S	HS	HS	S	S	HS	HS	HS
LR-15	HS	HS	S	HS	S	HS		S		S
LR-16	S	HS	S			HS	HS	HS	S	S
LR-17	HS	S	S	MS	S	S	S	HS	HS	S
LR-18	HS	S	S	S	HS	S	HS	MS	HS	S
LR-19	S	S		S	S	HS	HS	S		MS
LR-20	HS	MS	MS	HS	S	S		S	HS	S
LR-21		MS	MS	MS	HS	S	S	MR	HS	S
LR-22	HS	HS	S	S	S	HS	S	S	MS	S
LR-23	S	HS	MS	S	S		S	S	S	MS
LR-24	HS	HS	S	S	S	HS	S	HS	HS	HS
LR-70	HS	HS	S	MS	HS	S	HS	HS	HS	HS
LR-71		S	MS	S	S	MS	S	S	HS	HS
LR-72		S	S	HS	HS	HS	S	S	MS	S
LR-73	S	MS	S	S	S		S	S	S	S
LR-74	HS	S	S	MS	S		HS	MS	S	S
I		S	S	S	S	MS	S	S	HS	MS

Blank spaces in the table indicate non-availability of inoculated stalks for that particular treatment.

The results (table 64) showed that the isolates of C. falcatum differ in the symptoms they produce within the stalks of the same variety (S.P. Dwivedi and Kishan Singh).

(c) Sporulation.- Observations were also made on the extent of sporulation of the isolates used in pathogenicity studies. There was no correlation between the extent of sporulation and the linear spread of symptoms in the inoculated stalks. It appears that the sporulation on

*Srinivasan, K.V. and N.R. Bhat, Criteria for grading resistance of sugarcane varieties to red rot (Glomerella tucumanensis), Curr. Sci., 30:425 (1961).

oat-meal agar medium cannot be taken as an indication of virulence (S.P. Dwivedi and Kishan Singh).

iv) Response of stalks of different age-groups to inoculation with C. falcatum by the plug method.- Chona (1954)* reported "a great deal of variation of attack" of the disease in inoculated stalks of the same variety. With a view to studying whether this variation could be due to age of stalks, an experiment was undertaken with 14 varieties and using isolate D of C. falcatum. The stalks of different age-groups were tagged on emergence. These were inoculated by the standardised technique of plug inoculation in October and harvested in December, 1961 for measurement of linear spread of symptoms.

Table 65

Linear spread of red rot symptoms (cm) in the inoculated stalks of different age-groups

riety	Length of stalk in cm showing red rot symptoms in stalks aged - days							SE (±)	LSD at 5 per cent	Statistical significance
	62	79	94	108	123	144	160			
312	57.9	73.2	87.1	124.0	170.7	126.2	159.3	23.8	67.5	Sig. at 1 per cent
313	60.5	81.8	57.9	57.9	35.6	17.8	42.7			Not significant
331	28.7	50.0	33.8	25.9	36.1	39.1	15.7			8 "
419	27.9	25.4	22.9	17.8	21.1	34.8	59.4			"
453	-	40.7	20.3	19.1	14.7	50.0	31.8	-	-	"
527	117.6	55.4	70.4	84.6	58.2	127.0	160.3	23.6	68.0	Sig. at 5 per cent
617	39.9	43.9	24.1	56.9	42.7	21.6	65.5			Not significant
975	27.9	11.2	25.8	16.5	14.0	34.8	15.7	5.5	15.5	Sig. at 5 per cent
1038	-	96.5	53.3	36.1	45.0	126.5	60.7	17.4	50.3	"
1051	13.5	20.6	23.1	33.5	22.4	19.6	22.4			Not significant
1057	48.8	80.0	30.5	47.0	47.2	45.5	37.5	7.3	20.5	Sig. at 5 per cent
L.9	25.4	24.4	26.9	28.2	19.8	34.3	32.8			Not significant
.11	30.0	24.6	22.6	27.4	16.0	23.4	8.1			"
.14	65.0	54.9	47.0	42.7	50.8	52.6	53.3			"

The data (table 65) show that of the 14 varieties tested, differences were significant only in 4 varieties at 5 per cent and one variety at 1 per cent level. Even in these a uniform trend of differences is not evident (Kishan Singh and S.P. Dwivedi)

v) Laboratory technique of nodal inoculation.- That the red rot organism is capable of entering into a susceptible cane stalk at its nodal region has long been recognised (Butler 1906).** For testing the relative resistance of varieties to nodal infection, inoculations are usually done by dropping 1 to 2 ml of a concentrated conidial suspension in sterile water, into the cavity between the leaf-sheath and the cane stalk, in the rainy season. For finding out the extent and the foci of infection, the rind of inoculated nodes is gently scraped at harvest time and the extent of infection recorded. It has been however, felt by many workers that at times, proper infection does not take place even in varieties known to be highly susceptible under field conditions. The experiments conducted at this Institute on nodal inoculation in the last four years have also given rather erratic results. With a view to developing a reliable technique, a number of methods were tested in the laboratory: the one which gave the most satisfactory results is described here.

Apparently healthy, 9 to 11 months old stalks were harvested and carefully stripped; from these, 3- to 4-node pieces were drawn avoiding the top most, the lower most portions, the rooted nodes and the split internodes. Their cut ends and all the unavoidable splits on the inter-

*Chona, B.L., Ind. Jour. Agric. Sci., 24:301-315 (1954)
** Butler, E.J., Mem. Dep. Agric. India, Bot.Ser., 1(3):2-24 (1906)

nodes were sealed with wax. The cane pieces were washed, surface-dried and swabbed with alcohol. The nodes were then painted with a spore suspension from 7-10 days old cultures of isolate 'D' of C. falcatum; the pieces were then sealed in polyethylene bags and the bags kept at 27 ± 2°C against controls. Observations were recorded at intervals of 6, 10 and 12 days by taking the setts out and gently scraping the rind at the nodes. The infection by this method was found to be quite satisfactory. Several such tests were carried out.

The progress of infection was as follows:

After 6 days - Circular to irregular lesions more than 5 in number on root primordia, leaf scar or growth ring; lesions tending to coalesce; and reddening in tissues 3 to 6 mm deep.

After 10 days - Circular to irregular lesions more than 5 in number on root primordia, leaf scar or growth ring; lesions tending to coalesce; on splitting open the cane pieces, the internal tissues were found to be affected.

After 12 days - Infection much advanced and pronounced; all tissues discoloured and rotted; acervuli observed on growth ring and root primordia. Internal tissues showing typical symptoms of red rot.

Further work on the possible use of this technique for varietal screening and the grading of infection is in progress (C.L. Subramanian, M.B. Singh and Kishan Singh).

2. Wilt

i) Association of wilt with red rot organism.- Experiments were initiated to determine synergism between the red rot (C. falcatum) and the wilt (Cephalosporium sacchari) organisms, as these two organisms were very often isolated from the internal tissues of the same diseased stalk. 25 stalks in each of ten varieties (table 66) were inoculated separately with i) C. falcatum (isolate D), ii) C. sacchari, and iii) a mixture of the two organisms, respectively. The inoculations were done by the standardised plug method in September, 1960. The linear spread of symptoms was recorded after 4 months.

Table 66

Linear spread of disease symptoms in stalks inoculated with C. falcatum (red rot) and C. sacchari (wilt) alone and mixed

Variety	Spread of symptoms per cent length of stalks inoculated with		
	C. falcatum	C. sacchari	C. falcatum and C. sacchari
Co.312	79.8	24.1	77.2
Co.313	63.9	10.2	41.3
Co.419	21.3	19.6	32.8
Co.453	40.9	29.5	20.1
Co.513	35.1	17.1	38.9
Co.527	62.7	22.0	71.1
Co.617	29.4	16.9	28.6
Co.997	59.1	17.2	67.0
Co.S.245	25.6	18.9	33.8
Co.S.510	55.5	20.6	42.6

The data (table 66) show that the spread of visible symptoms of red rot is not enhanced by the presence of the wilt organism. However, this may be due to masking of wilt symptoms, since these are not as conspicuous as those of red rot.

The progress of the wilt fungus in a stalk was therefore determined by isolations from the tissues of stalks inoculated with wilt only. In the first instance samples were drawn from i) the apparently affected and ii) symptom less internodes of the inoculated stalks. The results indicated that the wilt organism was present in the top most discoloured (i.e. obviously affected) internodes, and also in the next higher one.

Side by side with this, the spread of C. sacchari was determined by isolations from tissues of stalks inoculated with mixed cultures in each of ten varieties. Leaving the inoculated internode, samples were drawn from every visibly affected internode. The experiment was done thrice.

The results showed that in almost all the varieties, C. sacchari had actually travelled through all the visibly affected internodes. The spread of C. sacchari in a stalk in the presence of C. falcatum was more than when it was alone (Kishan Singh and T.R. Budhraja).

Passage of the wilt fungus.- In a feeler experiment to determine the passage of the wilt fungus from one internode to the next, tissue samples were drawn from a number of internodes in the early stages of infection (i.e. when the stalk showed a few streaks of reddish-brown fibro-vascular bundles) in such a way that in one lot a piece of reddish-brown fibro-vascular bundle was included and in the other it was not. The samples were seeded on a suitable agar medium and incubated for 14 days. Tissue-samples having reddish-brown fibro-vascular bundles invariably yielded C. sacchari, whereas the other samples did not. This indicates that C. sacchari possibly travels through fibro-vascular bundles. Further investigations in this direction are in progress (Kishan Singh and T.R. Budhraja).

3. Smut

i) Varietal susceptibility to Ustilago scitaminea.- The reaction of 40 agronomically promising varieties against smut inoculation was studied. Healthy three-budded setts of each variety were immersed in a smut spore suspension (spore viability 90 per cent) for one hour and planted against uninoculated controls. Incidence of smut was recorded fortnightly till harvest (table 67) (T.R. Budhraja).

Table 67

Varieties classified on the basis of smut incidence following inoculation of setts

Incidence per cent	Varieties
0 - 5.0	Co.312, Co.449, Co.527, Co.617, Co.947, Co.957, Co.1122, Co.1144 and Co.1245.
5.1 -10.0	Co.313, Co.943 and Co.997.
10.1 -15.0	Co.419, Co.937, Co.963, Co.1087, Co.1161 and Co.1240.
15.1 -20.0	Co.945, Co.976, Co.1107, Co.1205, Co.1306, Co.S.510 and Co.1300.
20.1 -30.0	Co.1111, Co.1058, Co.1062, Co.1142, Co.1173, Co.1235, Co.1251 and Co.1304.
30.1 -40.0	Co.453, Co.965, Co.1254, Co.1305.
40.1 -60.0	Co.1207, Co.933 and Co.1236.
60.1 -80.0	Nil
80.1-100.0	Nil

ii) Physiology of Ustilago scitaminea.- In previous experiments (IISR Ann. Rep.1960-61, p.79), it was shown that 1(-)asparagine was an efficient source of nitrogen for the growth of U. scitaminea. The optimum concentration of this amine in the medium at the most favourable temperature and pH was worked out this year. The basal medium used for the purpose, comprised of dextrose 20 g, potassium di-hydrogen phosphate 1 g, potassium chloride 0.5 g, potassium sulphate 0.5 g, magnesium sulphate 0.5 g, ferrous sulphate 0.01 g, manganese chloride 0.01 g and distilled water 1000 ml. Twenty ml of the medium placed in each 90 mm petridish, was seeded with isolate LS-2 of U. scitaminea. After recording the diameters of the fungus colonies 21 days following incubation; intact fungal mats were separated from the medium, dried and weighed. It was observed that 0.1 per cent 1(-)asparagine in the medium was the most favourable for the development of the fungus (T.R. Budhraja and Kishan Singh).

Table 68

Growth of U. scitaminea at different levels of 1(-)asparagine

Asparagine in 1000 ml of basal medium (g)	Mean diameter of fungus colonies (mm)	Mean dry weight of fungal mats (g)
0.25	47	58.9
0.50	49	59.9
1.00	53	92.1
2.00	48	92.0
3.00	45	76.9
4.00	44	75.6
5.00	42	72.1

iii) Smut inoculation technique.- The present method of inoculating seed material with the smut organism for experimental purposes including varietal screening, is by dipping the setts in an aqueous suspension of viable chlamydospores before planting. Often erratic results are obtained, possibly because the inoculation technique is not perfect. Certain aspects of the technique have already been investigated for purposes of standardisation. This year, experiments were conducted to effect infection by facilitating a better penetration of the inoculum into the bud.

Setts of apparently healthy stalks of Co.527, Co.617, Co.947, Co.S.510 and P.11037 were placed in a chamber under negative pressure, and a suspension of viable chlamydospores was then allowed into the chamber to submerge the setts for 10 minutes. A similar lot of setts was submerged in spore suspension for 10 minutes at atmospheric pressure. In a third lot, the bud-scales were removed and viable chlamydospores were smeared on the exposed scales.

The setts so treated were then divided into two sub-lots in each case and incubated for 0 and 48 hours respectively, nd then planted. Each such sub-lot had 12 setts. The reaction of plants to the infection was assessed by the extent of incidence of smut.

The data presented in table 69 show that inoculation done after removing the outer scales of the buds and that done under negative pressure caused higher smut incidence than mere immersion. From this, it appears that the nearer the spores get to the growing point, the better are the chances of infection. The 48-hour preplanting incubation appears to lower the incidence of the disease. Further investigations on this method of inoculation are in progress (Kishan Singh and T.R.Budhraja).

Table 69

The effect of inoculations under negative pressure and by removal of scales on the incidence of smut

Variety	Per cent incidence of smut					
	Setts incubated for 0 hour after inoculation with			Setts incubated for 48 hours after inoculation with		
	Spore suspension under negative pressure	Applied after removing bud scales	Spore suspension under normal pressure (check)	Spore suspension under negative pressure	Applied after removing bud scales	Spore suspension under normal pressure (check)
Co.S.510	100	100	20	70	70	18
Co.617	74	91	18	49	62	11
Co.527	74	81	20	62	83	27
P.11037	50	50	nil	25	33	12
Co.947	nil	nil	nil	nil	nil	nil

4. Plant Parasitic Nematodes

i) Survey.- The survey for plant parasitic nematodes was continued. In 1959-60, certain species of parasitic nematodes associated

Table 70

Survey for nematodes parasitic on sugarcane in India: 1961-62

State	Number of samples analysed	Parasitic species
Punjab	134	Helicotylenchus erythrinae Helicotylenchus nannus Hoplolaimus (angustallatus) Pratylenchus sp. Tylenchorhynchus ornatus Xiphinema citri Longidorus elongatus Hemicriconemoides sp. Hemicycliophora sp.
Uttar Pradesh	17	Helicotylenchus erythrinae Hoplolaimus angustallatus Hoplo aimus sp. Pratylenchus penetraus Tylenchorhynchus sp. Xiphinema citri Hemicriconemoides sp. Longidorus elongatus
Madhya Pradesh	1	Helicotylenchus erythrinae Tylenchorhynchus sp. Pratylenchus sp. Trichodorus sp.
Madras	15	Helicotylenchus nannus Hoplolaimus (angustallatus) Tylenchorhynchus sp. Pratylenchus sp. Hemicriconemoides sp. Xiphinema brevicaudatum Trichodorus sp.

with sugarcane were recorded by this section, in the Nellikuppam area of Madras State (IISR Ann. Rep. 1959-60, p.74). Following this, nematodes parasitising sugarcane were found in samples obtained from or collected in Punjab, Uttar Pradesh, Bihar, Assam, Madhya Pradesh, Madras and Mysore (IISR Ann. Rep. 1960-61, p.83-85). This survey was continued with the samples collected personally whenever a sugarcane tract was visited and wherever nematode damage was suspected in a field. A large number of samples from Punjab were sent by the Economic Botanist (Sugarcane), Punjab. A summary of the survey is given in table 70.

In the majority of cases, subnormal growth of cane including various degrees of stunting, loss of chlorophyll from foliage, dryage of the tips and margins of leaves were observed (Kishan Singh).

Nematodes on other crops.- Samples of roots and soil from fields adjacent to the one cropped to sugarcane were also taken occasionally. In such fields at Jullundur, Punjab, species of Hoplolaimus, Tylenchorhynchus, Hemicriconemoides and Xiphinema were found in the root zones of citrus plants. At Padegaon, Maharashtra, species of Helicotylenchus, Tylenchorhynchus, Xiphinema and Longidorus were recorded around the roots of brinjal and chillies. At Perianaickenpalayam, Coimbatore, Madras, species of Hoplolaimus and Tylenchorhynchus were found in the rhizosphere of banana, and Helicotylenchus, Hoplolaimus and Tylenchorhynchus in the rhizosphere of onion (Kishan Singh).

ii) Effect and control of parasitic nematodes.- With a view to assessing the damage caused by parasitic nematodes and finding out possible methods of their control, a feeler experiment was conducted at the Sugarcane Experiment Station, Jullundur, Punjab, where facilities were kindly provided by the Economic Botanist (Sugarcane), Punjab. The soil at this experiment station in general is light and very well drained. A field in which the cane crop was showing sub-normal growth indicative of malnutrition was selected and soil samples were obtained from the root zones of the plants before the crop was harvested. High populations of plant parasitic nematodes were observed in the samples.

Seed bed was accordingly prepared for a second cane crop and an experiment was laid out in it with 3 treatments, viz. application of i) dichloropropane-dichloropropene at approximately 3 ml per m^2 applied with an injector-gun at 22 cm depth, followed by a light sprinkling of water with a rose can ; ii) sodium methyl dithiocarbamate (Vapam of Rohm and Hass of Philadelphia) 0.61 litres per m^2 as a 1.7 per cent suspension in water, and iii) control. Due to the non-availability of chemicals earlier, the above fumigation treatments had to be delayed till 12th April, 1962.

Table 71

The population of nematodes in the experimental plots

Treatment	Before fumigation 12th April 1961	At planting 2nd May 1961	At the end of season 8th January 1961
Dichloropropane-dichloropropene	185	14	261
Sodium methyl dithiocarbamate	185	24	303
Control	185	200	385

Soil samples were collected before applying the chemicals and at planting, and at frequent intervals thereafter for analysis of nematode population.

The data (table 71) show that the population of nematodes was brought down considerably by the treatments, but that it also built up again. The experiment was harvested on 17th February, 1962. For purposes of comparison, the cane from each plot alone was taken.

Table 72

Effect of chemical control of nematodes on the yield of sugarcane (Jullundur: 1961-62)

Treatment	Yield of cane in one row 4 m in kg	Number of stalks in one row	Mean height of stalks (cm)	Mean number of internodes per stalk
Dichloropropane-dichloropropene	1.08	36	103.6	10.7
Sodium methyl dithiocarbamate	0.88	26	111.1	11.4
Control	0.56	24	88.5	10.3

Co.976; planted 27th April 1961.

Table shows that the application of the two chemicals has markedly increased the yield of sugarcane, possibly because of the control of nematode-populations. The root systems of the plants in the treated plots were also better than those of the untreated. The maximum attack of nematodes seems to be in the earlier stages of sugarcane growth (Kishan Singh).

Miscellaneous

Short course in Plant Nematology.- A short course in plant nematology was given in the Section from October 9 to October 15, 1961. It was attended by fourteen persons from 11 research organisations in 8 states. Special instruction was given in the techniques of sampling isolation, preservation, preliminary identification and the basic principles of laboratory and field experiments on nematode infection and damage. The nematode and micro-organism associations forming disease complexes were discussed in detail (Kishan Singh).

A deputee from the Sugarcane Research Scheme, Madhya Pradesh, was trained in the techniques of inoculations for major sugarcane diseases with a view to screening varieties (Kishan Singh and C.L. Subramanian).

Maintenance of Cultures.- Cultures of C. falcatum, U. scitaminea, C. sacchari and Marasmius sp. were maintained and multiplied according to requirements. Fresh isolations were made and studied from material obtained from different cane tracts (S.P. Dwivedi, T.R. Budhraja, C.L. Subramanian and M.M. Tiwari).

Infected plant and soil material was received frequently from various sugarcane-growing areas of the country. It was examined and analytical and diagnostic reports were sent to the parties concerned, wherever needed (Kishan Singh, C.L. Subramanian, T.R. Budhraja and S.P. Dwivedi).

The planting material of sugarcane varieties sent to other States or countries was examined for diseases and phyto-sanitary certificates were issued accordingly (C.L. Subramanian and S.P. Dwivedi).

ENTOMOLOGY

(A.N. Kalra : Entomologist)

1. Studies on toxicity and persistence of insecticides

i) Toxicity of different insecticides in relation to newly-hatched larvae of Scirpophaga nivella F.- Newly-hatched larvae of S. nivella were exposed, in separate lots, to glass surfaces treated with

Table 73

Mortality of newly-hatched larvae of S. nivella on exposure to surfaces sprayed with different insecticides

Treatment	Larvae exposed after spraying	Cumulative mortality per cent among the larvae (hours) after exposure (period of exposure 15 min)			
		0 hour	6 hours	24 hours	48 hours
Endrin 0.1 per cent emulsion	15 min	16.7	50.0	100.0	
	1 day	41.7	100.0	100.0	
	2 days	41.7	66.7	100.0	
	3 "	41.7	100.0	100.0	
	4 "	25.0	100.0	100.0	
	6 "	8.3	83.3	100.0	
	8 "	16.7	83.3	100.0	
	10 "	nil	33.3	100.0	
	12 "	"	75.0	100.0	
	14 "	"	83.3	100.0	
	16 "	"	83.3	100.0	
	18 "	"	8.3	91.7	91.7
	20 "	"	16.7	66.7	66.7
	24 "	"	nil	50.0	50.0
	28 "	"	"	33.3	33.3
Telodrin 0.1 per cent emulsion	15 min	50.0	100.0	100.0	
	1 day	33.3	100.0	100.0	
	2 days	33.3	66.7	100.0	
	3 "	41.7	100.0	100.0	
	4 "	41.7	100.0	100.0	
	6 "	nil	58.3	100.0	
	8 "	"	50.0	100.0	
	10 "	"	33.3	75.0	75.0
	12 "	"	66.6	83.3	83.3
	14 "	"	75.0	75.0	75.0
	16 "	"	41.7	41.7	41.7
	18 "	"	nil	8.3	8.3
	20 "	"	"	nil	nil
	24 "	"	"	"	"
	28 "	"	"	"	"
Malathion 0.1 per cent emulsion	15 min	41.7	100.0	100.0	
	1 day	50.0	100.0	100.0	
	2 days	16.7	50.0	100.0	
	3 "	58.3	100.0	100.0	
	4 "	41.7	100.0	100.0	
	6 "	33.3	100.0	100.0	
	8 "	25.0	91.7	100.0	
	10 "	nil	25.0	100.0	
	12 "	"	83.3	100.0	
	14 "	"	75.0	100.0	
	16 "	"	83.3	100.0	
	18 "	"	nil	75.0	75.0
	20 "	"	"	33.3	33.3
	24 "	"	"	nil	nil
	28 "	"	"	"	"
Control		nil	nil	nil	nil
LSD at 5 per cent level				25.8	

0.1 per cent emulsions of endrin, telodrin and malathion immediately after spraying, and later at graded intervals, upto 28 days after treatment. The period of exposure in each case was 15 minutes. The number of larvae under each series was 12 per unit of 3 petri dishes. During the period of the study, the laboratory temperature ranged between 22°C and 28°C and the mean relative humidity between 42 and 66 per cent.

Effective residual toxicity yielding 100 per cent mortality of the newly-hatched larvae of top borer within 24 hours of exposure to the treated surfaces, was observed to last 16 days, 8 days and 16 days in case of endrin, telodrin and malathion 0.1 per cent emulsion sprays respectively.

ii) Comparative toxicity of endrin, telodrin and malathion in relation to grown-up larvae of Chilotraea auricilia Ddgn.:- The grown-up larvae of C. auricilia were exposed, in separate lots, to treated glass surfaces, immediately after spraying and 24, 48, 96 and 144 hours after spraying. The period of exposure in each case was 1 hour. The number of larvae in each series was 12 per unit of 3 petri dishes. Observations on mortality were recorded 24, 48 and 96 hours after exposure. During the period of the study, the laboratory temperature ranged between 29°C and 33°C, and the mean relative humidity between 22 and 42 per cent.

Table 74

Mortality of grown-up larvae of C. auricilia exposed to surfaces sprayed with different insecticides

Treatment	Larvae exposed after ____ of spraying	Cumulative mortality per cent among the larvae ____ (hours) after exposure (period of exposure 1 hr)		
		24 hours	48 hours	96 hours
Endrin 0.1 per cent emulsion	15 min	41.7	75.0	100.0
	24 hr	8.3	58.3	83.3
	48 "	8.3	25.0	41.7
	96 "	8.3	16.7	50.0
	144 "	8.3	16.7	41.7
Telodrin 0.1 per cent emulsion	15 min	50.0	58.3	100.0
	24 hr	33.3	58.3	58.3
	48 "	16.7	25.0	58.3
	96 "	50.0	58.0	58.0
	144 "	nil	8.3	8.3
Malathion 0.1 per cent emulsion	15 min	66.7	91.7	100.0
	24 hr	50.0	58.3	58.3
	48 "	25.0	41.7	41.7
	96 "	8.3	8.3	16.7
	144 "	nil	nil	8.3
Control		nil	nil	8.3
LSD at 5 per cent level				33.6

In each of the 3 treatments, complete mortality of larvae was observed 96 hours after exposure when the larvae were exposed to the treated surfaces immediately after spraying. Exposures made 48 hours after treatment and later, showed low mortality (A.N. Kalra and J.P. Chaudhary).

2. Studies on the control of moth borers

i) Shoot borer, Chilotraea infuscatellus Snell.-

(a) Trials with chlorinated hydrocarbon insecticides.- Two experiments for the control of shoot borer were laid out. In one experiment insecticidal dusts and in the other emulsions were applied over the setts in the furrows at the time of planting. Germination counts were taken 6 and 8 weeks after planting and observations on attack of shoot borer, twelve weeks after planting, i.e. in May, 1961.

Table 75

Efficacy of different chlorinated hydrocarbon insecticides against shoot borer, C. infuscatellus

Treatment	Dose per hectare (actual insecti-cide)	Per cent germination weeks after planting		Per cent incidence of shoot borer
		6 weeks	8 weeks	
Experiment with dusts				
Aldrin	1.0 kg	30.4	38.5	5.4
BHC	"	27.7	40.0	16.3
Gamma BHC (lindane)	0.5 kg	28.3	36.2	5.9
"	1.0 kg	36.0	43.1	3.1
DDT	"	27.0	39.1	18.1
Heptachlor	"	29.3	37.1	10.3
"	0.5 kg	30.8	38.8	10.3
Control	-	27.9	37.3	26.7
LSD at 1 per cent level				11.9
Standard error		3.1	2.9	
Experiment with emulsions				
Aldrin	1.0 kg	20.7	37.2	6.7
Dieldrin	"	26.2	44.5	6.7
Gamma BHC	"	22.2	39.9	1.9
"	0.5 kg	24.1	43.3	3.6
DDT	1.0 kg	24.5	38.9	13.4
Heptachlor	"	26.4	43.6	4.9
"	0.5 kg	23.7	42.1	5.3
Control	-	21.0	39.1	15.3
LSD at 1 per cent level				11.5
Standard error		2.8	2.8	

4 randomised blocks; plot size 67 m^2 ; Co.975; planted 18th February, 1961

The differences in germination under various treatments were statistically non-significant. Attack of shoot borer was least in plots treated with gamma BHC both as dust or emulsion. The next best treatments were aldrin and heptachlor applied as dust. All these treatments were significantly superior to control (A.N. Kalra, P.N. Avasthy and S. Kumar).

(b) Trials with systemic insecticides.- Soil application and foliar spray of thiometon (ekatin), metasystox and gusathion, each as 0.1 per cent emulsion, were tried in an experiment for the control of shoot borer (table 76).

None of the treatments proved effective against the pest (A.N. Kalra, P.N. Avasthy and S. Kumar).

Table 76

Effect of some systemic insecticides against the shoot borer C. infuscatellus

Treatment 0.1 per cent emulsion	Mode of application	Shoot borer attack one month after treatment	
		Per cent incidence	Seizures per hectare
Thiometon (ekatin)	Foliar	21.6	13000
-do-	Soil	20.0	15612
Metasystox	Foliar	18.0	10575
-do-	Soil	32.0	19200
Gusathion	Foliar	18.0	11537
-do-	Soil	24.3	15825
Control	-	24.6	15737

4 randomised blocks; plot size 200 m^2; Co.S.510; planted 19th February, 1961

ii) Stalk borer, Chilotraea auricilia Ddgn..- An experiment for the control of stalk borer was carried out. The insecticidal sprays (table 77) were applied at 1000 litres per hectare monthly in September, October and November, synchronising as far as possible, with the rush of moth emergence and oviposition. Endrin 0.1 per cent emulsion spray gave significantly better results than rest of the treatments (A.N. Kalra and M.C. Gupta).

Table 77

Efficacy of different insecticides against stalk borer, C. auricilia

Treatment	Per cent incidence of stalk borer		Increase in incidence since September	Per cent internodes attacked in the infested canes (at harvest)
	Before treatment (Sept.)	After treatment (Dec.)		
Endrin 0.1 per cent emulsion	19.5	33.7	14.2	11.1
Endrin + diazinon 0.1 per cent emulsion	15.3	43.6	28.3	11.6
DDT + malathion 0.1 per cent emulsion	12.8	56.8	44.0	13.4
DDT 0.2 per cent emulsion	19.1	54.2	35.1	13.0
Gamma cereclor 0.2 per cent suspension	18.1	43.4	25.3	11.3
Heptachlor 0.2 per cent emulsion	13.0	56.0	43.0	13.5
Sevin 0.2 per cent suspension	19.4	58.1	38.7	12.8
Chloricide 0.2 per cent suspension	16.9	66.5	49.6	13.9
Thuricide (microbial insecticides) 2.5 kg per hectare	17.0	53.3	36.3	14.1
Control	20.6	61.1	40.5	15.8
LSD at 5 per cent level			10.9	

4 randomised blocks; plot size 200 m^2; Co.975; planted 18th November, 1960

3. Treatment of seed-cane against C. auricilia

Soaking of the infested seed-cane in dipterex 0.2 per cent solution for two hours had shown high mortality among the C. auricilia larvae without adversely affecting germination of the buds (Ann. Rep. IISR, 1960-61, p.91). These studies were continued in 1961-62. Insecticides which had adversely affected germination earlier were tried in lower strengths. Dipterex 0.1 per cent solution in combination with aretan, organomercurial compound, was also included in these trials.

Table 78

Mortality of C. auricilia pupae and larvae within the cane as a result of soaking in different insecticides

Treatment	Mortality among pupae and larvae			
	1 hour soaking		2 hours soaking	
	Per cent pupae killed	Per cent larvae killed	Per cent pupae killed	Per cent larvae killed
Endrin 0.05 per cent emulsion	44.0	100.0	66.6	100.0
Gamma BHC + DDT 0.05 per cent emulsion	66.6	81.8	100.0	100.0
Diazinon " " " "	73.3	93.3	91.6	95.0
-do- 0.1 " " "	81.2	93.1	100.0	100.0
Telodrin 0.05 " " "	62.5	94.2	75.0	100.0
Malathion " " " "	66.6	78.1	66.6	84.6
Malathion 0.1 " " "	87.5	90.9	90.0	100.0
Dipterex 0.1 " " solution	35.7	73.9	30.0	91.7
" 0.2 " " "	36.4	95.2	50.0	100.0
" 0.1 per cent solution + aretan 1 kg in 400 lit	40.0	87.2	60.0	100.0
Water soaking	13.3	27.8	28.6	40.0
Control (no soaking)	15.6	32.9	15.6	32.9

While almost all treatments gave high kill of larvae, mortality among the pupae was high only under gamma BHC + DDT, diazinon and telodri all in 0.05 per cent emulsions with 2 hours soaking, and under malathion and diazinon 0.1 per cent emulsions with even 1 hour soaking.

All treatments except diazinon 0.1 per cent emulsion gave bette germination than the unsoaked control (table 79). Two hours soaking in telodrin 0.05 per cent emulsion, malathion 0.1 per cent emulsion, and dip terex 0.1 per cent solution + aretan 1 kg in 400 lit, resulted in significantly higher germination than rest of the treatments.

Summing up, soaking of cane setts for 2 hours in gamma BHC + DDT, diazinon, or telodrin, 0.05 per cent emulsion in each case, or in malathion 0.1 per cent emulsion, caused high mortality among the larvae and pupae without adversely affecting the germination of buds (A.N. Kalra and M.C. Gupta).

4. Studies on biology

i) Stalk borer, C. auricilia.- Previous studies at the Indian Institute of Sugarcane Research had shown that in May, the larval and pupal populations of the stalk borer are almost reduced to nil in ratoon sprouts, although in March-April the pest is usually met with. Studies in 1962 revealed that the grown-up larvae of the first brood migrate to ratoon stubbles towards the end - April and remain there till about end - May. Their pupation appears to start in the later half of May, and moth emergence in June.

This suggests that under central U.P. conditions, there is only one brood of the pest from February-March to end of June, and not two as had been generally believed. Possibly the low atmospheric humidities and high temperatures in May being unfavourable to the pest, the grown-up caterpillars migrate to the stubbles. This explains the absence of fresh attack during May (A.N. Kalra and J.P. Chaudhary).

ii) Top borer, S. nivella.- The pest remained active from about the middle of February to the middle of October, after which it entered hibernation within the cane tops. It passed through 5 broods during the

Table 79

Effect of insecticidal soaking on germination of buds

Treatment (Soaking with)	Period of soaking (hr)	Per cent germination weeks after planting		
		4	6	8
ndrin 0.05 per cent emulsion	1	38.6	51.5	55.4
amma BHC + DDT 0.05 per cent emulsion	2	37.0	49.2	54.6
iazinon (Basudin) " " "	2	42.5	51.4	54.6
" 0.1 " " "	1	28.2	36.5	38.9
elodrin 0.05 " " "	1	34.6	47.5	53.0
" " " "	2	52.5	59.4	64.2
alathion 0.1 " " "	1	36.1	48.4	51.8
" " " "	2	56.0	62.1	65.5
ipterex 0.1 per cent solution + aretan 1 kg in 400 lit	2	62.8	67.6	70.9
ater	1	31.6	45.3	50.5
ontrol (no soaking)		28.7	44.8	48.8
SD at 5 per cent level				6.6

randomised blocks; no. of buds per plot 360; Co.S.510; planted 7th March, 1962

year . Rush of moth emergence of different broods was observed in (i) the 1st and 2nd weeks of March, (ii) the 2nd week of May, (iii) the 3rd week of June, (iv) the last week of July and (v) the 3rd and 4th weeks of September. Sex ratio among the moths reared in the laboratory for various broods was as given in table 80. The proportion of females was higher in all the broods.

Table 80

Sex ratio among top borer moths of various broods

Brood	Per cent males	Per cent females
I	47.2	52.8
II	47.2	52.8
III	43.3	56.7
IV	45.8	54.2
V (over-wintering brood)	36.6	63.4

In the course of studies on the biology of the pest, it was observed that in January, when atmospheric temperature ranged between 5°C and 25°C, if the hibernating caterpillars lying within the infested cane tops, were removed from the field and kept at 30°C temperature and 60 per cent relative humidity in the laboratory, they immediately resumed activity, and in the case of fully grown larvae, the 'exit holes' were also noticeable within 60 to 75 hours. Moth emergence took place 13 to 22 days after formation of the exit hole (A.N. Kalra and J.P. Chaudhary).

Infructuous attack of top borer

Field observations on the incidence of top borer show that from July to September, when growth of the crop is vigorous, in many cases the young larva after boring through the mid-rib of the last-opened leaf and entering the top portion of the cane, fail to reach the growing point. Such canes escaped damage and continued their normal growth. It is evident that rapid growth of the shoot during monsoon, in some cases, out-paces the movement of the young top borer larvae towards the growing point.

To study the extent of such infructuous attack in canes, observations were recorded on Co.S.510, a highly susceptible variety, on spring-planted, autumn-planted and ratoon crops. The autumn-planted crop showed the highest percentage of infructuous attack (table 81).

Table 81

Top borer incidence and per cent infructuous attack in spring-planted, autumn-planted and ratoon crops (Co.S.510).

Brood	Spring planted			Autumn planted			Ratoon		
	Stalks attacked per cent total no. of stalks	Stalks attacked successfully per cent total no. of stalks	Stalks escaping damage per cent total no. of attacked stalks	Stalks attacked per cent total no. of stalks	Stalks attacked successfully per cent total no. of stalks	Stalks escaping damage per cent total no. of attacked stalks	Stalks attacked per cent total no. of stalks	Stalks attacked successfully per cent total no. of stalks	Stalks escaping damage per cent total no. of attacked stalks
3rd	8.4	7.3	12.6	2.7	1.7	37.7	3.6	2.7	23.0
4th	19.4	15.9	18.3	8.3	5.6	32.4	8.1	5.5	31.2
5th	25.1	21.9	13.0	11.1	8.4	25.5	10.1	8.0	23.6

To study the comparative behaviour of some of the popular varieties in this regard, observations were recorded in the final varietal trial of the Agronomy section.

Table 82

Extent of infructuous attack of top borer in different varieties

Variety	4th brood attack (July-August)			5th brood attack (Sept.-October)		
	Stalks attacked per cent total no. of stalks	Stalks attacked successfully per cent total no. of stalks	Stalks escaping damage per cent total no. of attacked stalks	Stalks attacked per cent total no. of stalks	Stalks attacked successfully per cent total no. of stalks	Stalks escaping damage per cent total no. of attacked stalks
(a) Varieties susceptible to top borer attack						
Co.S.510	20.8	16.7	19.6	21.1	19.4	8.0
Co.1308	17.9	13.3	25.7	13.5	10.8	23.9
Co.997	15.5	10.8	30.8	11.4	9.2	22.0
(b) Varieties comparatively resistant to top borer attack						
Co.1149	4.8	2.5	48.4	9.3	5.6	39.9
Co.975	8.6	4.2	50.8	7.2	5.3	27.0
Co.L.29	9.9	6.0	40.0	8.5	4.6	30.9

Apart from the incidence itself being less in the comparatively resistant varieties, the percentage of canes escaping damage was also higher. This was true of both the 4th brood and 5th brood attack. Moreover the shoots attacked during August (4th brood) showed higher percentage of infructuous attack than those attacked in September-October (5th brood), probably because of more vigorous and rapid growth in the former period (A.N. Kalra and J.P. Chaudhary).

5. Studies on the assessment of losses caused by top borer in its different broods

(a) Loss in yield of cane.- Infestation by the first two broods of the top borer occurring in the premonsoon period when the crop is young, kills the shoots. Attack of the subsequent broods from July onwards when cane formation has started, arrests further growth of the affected shoots. To assess the losses caused by the 3rd, 4th and 5th broods of the pest, a seriously-infested field measuring about 200 m^2 was selected in Barabanki area. All the canes attacked by each of the three broods, as also the healthy canes, were labelled individually. At harvest in February, 1962, all the canes in each category were counted and weighed separately. The average weight per cane of each category and of unattacked cane were worked out. The losses in weight as a result of attack were calculated separately for each brood attack, as the difference between the weight of the unattacked cane and the cane attacked in each brood.

Table 83

Loss in weight of cane as a result of top borer attack

Particulars	Unattacked canes	Canes attacked in the 3rd brood	Canes attacked in the 4th brood	Canes attacked in the 5th brood	Total
1. Number of millable canes per hectare	14,832	54,537	26,026	18,897	1,14,292
2. Per cent of the total	13.0	47.7	22.8	16.5	100
3. Average weight per cane in g	522	173	487	522	1,704
4. Actual yield per hectare in m tons	7.8	8.4	12.9	9.8	38.9
5. Expected yield per hectare in m tons (if all the canes were healthy)	7.8	28.5	13.6	9.8	59.7
6. Loss per hectare in m tons	-	20.1	0.7	-	20.8
7. Per cent loss in yield	-	71.0	5.1	-	-

Average loss in yield of the canes attacked in the 3rd brood was as high as 71.0 per cent of that which those canes would have yielded if they had not been attacked. The canes attacked in the fourth brood showed a loss of 5.1 per cent as compared to unattacked canes, while 5th brood attack occurring in October caused no loss at all, probably because by then the stalks had attained their full growth. If possible compensation is not taken into account, the total loss in yield on account of borer attack can be assumed to be about 20.8 m t per ha in this crop, or about 35 per cent. In addition, there was a loss of about 1.05 metric tons of sugar also per ha (table 84) (A.N. Kulra and J.P. Chaudhary).

The quality of juice of healthy and attacked canes was also tested.

6. Study of methods for assessing pest incidence and populations

Further scrutiny of the data collected earlier on incidence and population of *C. auricilia* in sugarcane showed that among the different sampling units varying from 0.3 m (1 ft) to 3.6 m (11 ft) of the crop row length, those measuring 1.5 m (5 ft) and 1.8 m (6 ft) gave the highest efficacies for determining the number of infested as well as total stalks in a field (B.P. Gupta, P.N. Avasthy and R.S. Srivastava).

Observations on the incidence of shoot borer, *C. infuscatellus* were recorded in June, 1961 at the Institute farm in a Co.1111 plot measuring 435 m^2. The locations of individual clumps and shoots, both healthy and attacked, were recorded row-wise for finding out methods of assessing shoot borer incidence. Statistical scrutiny of the data collected is in progress (P.N. Avasthy and T.N. Srivastava).

Table 84

Effect of top borer attack on juice-quality

Particulars	Healthy canes	Canes attacked by		
		3rd brood	4th brood	5th brood
Brix	19.12	13.36	17.06	18.06
Pol	16.77	9.71	14.43	15.28
Per cent available sugar*	12.31	6.02	9.77	10.34
Expected sugar per hectare in metric tons (if all the canes were healthy)**	0.96	1.03	1.59	1.21
Actual sugar per hectare in metric tons**	0.96	0.51	1.26	1.01
Loss per hectare in metric tons	nil	0.52	0.33	0.20
Total loss per hectare in metric tons	-	1.05		

* Calculated according to Winter and Carp formula.

** Sugar per hectare = $\frac{\text{Per cent available sugar x yield per hectare}}{100}$

7. Studies on parasites of sugarcane pests

(a) Parasierola sp. .- A new bethylid parasite Parasierola sp. was recorded on the caterpillars of the armyworm, Pseudaletia (Cirphis) unipuncta Haw. at the Institute farm during the period October, 1961 to February, 1962. External morphology of the adult parasite was studied and the male and female genitalia were described.

Parasierola sp. is a gregarious ectoparasite. It was found to attack the third and fourth stage caterpillars of the armyworm. The male parasites emerged a day or so earlier than the females. The life span of the adults, when fed on boiled raisins, was 1 to 3 weeks under laboratory conditions. Mating occurred immediately after emergence and the female started laying eggs within 48 hours of mating. In the laboratory, one female was observed to lay as many as 25 eggs on one host caterpillar. The eggs were laid longitudinally in 2 to 3 parallel rows on the lateral side with their anterior ends pointing towards the head of the caterpillar.

Table 85

Duration of different stages of the bethylid parasite, Parasierola sp.

Stages of life history	Duration (in days)	
	at 12° to 24°C temp. and 28 to 56 per cent RH	at 28°C temp. and 60 to 62 per cent RH
Incubation	2-3	0.5-1
Larval period	5-8	1.5-3
Prepupal period	4-7	2-3
Pupal period	15-28	4-7
Total life-cycle	26-46	8-14
Longevity of adults	7-21	4-8

The parasite larva feeds on the body fluids of the host larva, causing shrinkage in the latter. The parasitised caterpillar hangs limp on sugarcane stalk with a number of parasite larvae sticking on its

body. The parasites leave the host caterpillar only after they have completely drained out the body fluids.

Before pupation all the parasite larvae present on one host caterpillar spin oblong cocoons simultaneously. The freshly-formed cocoon and the pupae are white, but turn yellowish brown after a few days.

The life-history of the parasite was studied (table 85) (P.N. Avasthy and J.P. Chaudhary).

(b) Isotima javensis Rew.- Parasitisation of grown-up larvae of top borer by I. javensis was observed throughout the period of activity of the pest. Per cent parasitisation as recorded for the 1st, 2nd, 3rd, 4th and 5th broods of the pest was 1.3, 18.4, 13.9, 7.5 and 27.6, respectively.

In the laboratory the parasite completed one life-cycle in 14 to 22 days at an average maximum temperature of 30.2°C and mean relative humidity 74 per cent.

(c) Other larval parasites of top borer.- The extent of parasitisation by the other parasites was as given in table 86.

Table 86

Parasitisation of top borer larvae by Vipio deesae, Rhaconotus scirpophagae and Elasmus zehntneri

Top borer brood	Per cent parasitisation by		
	V. deesae	R. scirpophagae	E. zehntneri
1st	nil	3.7	nil
2nd	4.1	2.0	2.0
3rd	5.7	1.6	nil
4th	1.9	7.8	1.9
5th	nil	nil	nil

The egg parasite, Telenomus beneficiens Zhnt. was recorded on the eggs of top borer throughout the period of activity of the pest. Per cent egg-mass parasitisation for the 5 successive broods of the pest was 11.7, 26.6, 21.3, 19.2 and 27.6 (A.N. Kalra, P.N. Avasthy and J.P. Chaudhary).

Apanteles flavipes Cam. was recorded on larvae of C. auricilia from October, 1961 to March, 1962. Per cent parasitisation varied from 4 in March to 21 in November. Its biology was studied at 20°C, 28°C and 32°C, the relative humidity ranging between 60 and 80 per cent.

Table 87

Duration of various stages of Apanteles flavipes at different temperatures

Temperature	Relative humidity per cent	Incubation period (hr)	Larval period (days)	Pre-pupation period (hr)	Pupation period (days)
22.0°C	70-80	36-48	15-20	12-48	7-10
28.0°C	60-70	28-38	9-15	12-36	6-9
32.0°C	60-70	18-30	7-11	6-12	6-7

Duration of total life cycle was 24 to 34 days at 22°C and 14 to 20 days at 32°C. The females emerging from the larvae and pupae reared at 32°C were found to be sterile. In the laboratory, the number of C. auricilia larvae parasitised by a single parasite was 6 to 8 and upto 40 adult parasites were reared from a single host larva (A.N. Kalra and R.C. Srivastava).

About 1000 cocoons of E. melanoleuca, a parasite of Pyrilla adults and nymphs, were collected from the farm of the Indian Institute of Sugarcane Research, Lucknow in September, 1961 and despatched to Sehore in Madhya Pradesh where a serious infestation of Pyrilla was met with at the time. The green muscaradine Metarrhizium anisopliae Metsch was later observed parasitising the nymphs and adults of Pyrilla at Sehore. Epipyrops adults emerged from some of the cocoons and egg laying by the females was also noticed, but the parasite failed to establish itself on account of very high mortality among the Pyrilla adults and nymphs as a result of infection by the green fungus (P.N. Avasthy and A.K. Mehrotra).

Table 88

Behaviour of different varieties towards the incidence of top borer and stalk borer

Variety	Top borer (on stalk basis)			Stalk borer	
	4th brood attack	5th brood attack	Total	On stalk basis	On internode basis
Co.449	11.4	10.3	21.7	50.9	14.3
Co.453	6.8	4.8	11.6	30.7	11.4
Co.785	7.2	7.2	14.4	31.7	10.7
Co.975	4.2	5.3	9.5	44.3	12.3
Co.997	10.8	9.2	20.0	34.9	13.4
Co.1118	5.6	4.2	9.8	44.2	11.3
Co.1149	2.5	5.6	8.1	30.9	10.2
Co.1155	4.6	12.7	17.3	27.1	10.2
Co.1176	7.6	10.8	18.4	59.8	15.1
Co.1233	5.6	4.9	10.5	56.9	15.9
Co.1254	10.9	11.9	22.8	30.7	10.7
Co.1305	5.6	6.3	11.9	18.3	10.2
Co.1306	11.9	9.6	21.5	38.0	10.9
Co.1308	13.3	10.8	24.1	41.8	12.5
Co.1319	12.0	8.7	20.7	56.9	14.4
Co.1321	11.4	12.5	23.9	35.5	13.7
Co.S.510	16.7	19.4	36.1	35.7	11.5
Co.S.541	7.0	10.9	17.9	34.8	16.2
Co.S.555	8.2	11.0	19.2	28.2	10.2
Co.S.568	8.5	10.9	19.4	40.0	14.3
Co.L.29	6.0	4.6	10.6	34.2	11.0
B.O.17	10.7	10.5	21.2	31.6	14.3
C.P.34/79	7.2	5.5	12.7	10.9	8.5
C.P.49/50	8.0	8.1	16.1	31.7	10.2

Insect collection and identification

Periodic collection of different sugarcane pests and casual insect visitors to sugarcane crop, was continued through light traps at night and visits to the field in daytime. 27 new species of insects were added to the Institute collection. Their identification was arranged through the courtesy of the Forest Research Institute, Dehra Dun and the Commonwealth Institute of Entomology, London (A.N. Kalra, M.C. Gupta and T.N. Srivastava).

8. Study of behaviour of new Co. varieties towards pest incidence

Twenty four varieties in the final varietal trial of the Agronomy Section were tested for borer incidence (table 88).

Co.S.510 had the highest attack of top borer; Co.1149, Co.1118, Co.975, Co.1233 and Co.L.29 were found comparatively resistant. High attack of C. auricilia was met with on Co.1176, Co.1233, Co.1319 and Co.449, while Co.1305 and C.P.34/79 were found comparatively resistant (A.N. Kalra, J.P. Chaudhary and M.C. Gupta).

Meteorological data for 1961-62
as recorded at the Indian Institute of Sugarcane Research, Lucknow.

Calendar months	Av. max temp °C	Av min temp °C	Av per cent rel humidity			Av soil temp °C			Rainfall mm	Number of rainy days	Av. wind vel km p h	Av evap (24 hrs) cc	Hrs of sunshine
			Morning (7.06 hrs)	Evening (14.06 hrs)	Mean	5 cm depth	15 cm depth	30 cm depth					
1961													
une	39.7	28.4	56	35	45	39.2	38.4	36.3	15	3	7.7	17.7	240
ıly	32.7	26.3	88	68	78	37.1	33.8	32.6	373	16	4.3	5.1	197
ugust	31.9	25.7	94	78	86	34.2	31.3	31.1	483	23	2.1	2.3	125
eptember	31.6	24.2	90	68	79	34.8	32.4	31.2	171	10	2.4	3.8	237
ctober	30.1	21.9	88	55	71	31.3	27.6	26.8	276	9	2.6	4.1	243
ovember	26.8	12.8	89	48	69	27.4	22.2	21.4	nil	nil	1.5	4.6	276
ecember	21.8	5.4	90	49	69	21.1	17.3	17.1	nil	nil	2.8	4.5	219
1962													
anuary	20.5	5.5	92	44	68	20.9	15.3	14.8	38	2	3.1	4.6	266
ebruary	24.3	10.4	87	42	64	25.9	19.7	18.3	5	2	2.8	5.2	223
arch	31.3	14.4	65	22	44	33.8	26.6	23.6	nil	nil	6.2	9.1	224
pril	36.3	20.1	51	22	36	41.4	33.3	30.2	nil	nil	6.0	12.2	301
ay	40.9	24.9	47	19	33	44.8	37.4	34.3	5	1	5.7	17.6	318
otal	-	-	-	-	-	-	-	-	1366	66	-	-	2869

TECHNICAL PROGRAMME FOR 1962-63

Agronomy

1. Studies in germination

   i) Gradients of germination in setts.

   ii) Effects of moisture depletion and conservation in setts on the germination of buds.

   iii) Estimate of loss of weight through various surfaces of 3-budded sett.

   iv) On the use of different types of polyethylene film on the sprouting of buds.

2. Studies in tillering

   i) On the absolute spatial relationships of cane clumps.

   ii) Plant density in ratoon crop in relation to seedrate in autumn-planted cane.

   iii) On the effect of number of buds on a sett.

3. Studies on conservation of moisture for sugarcane crops

   On the use of soil cover and trash-veins in alkaline soils

4. Studies on cultural systems and practices of sugarcane

   i) On the combined effect of strip-tilling, slip setts and trash-veins on yield and quality of sugarcane after wheat.

   ii) On the effect of rotovation in ratoons.

5. Studies on the control of weeds in sugarcane fields

   i) Studies on the chemical and mechanical control of weeds.

   ii) Response of varieties to Dowpon.

   iii) On the use of Esso Agricultural mulch.

6. Fertilisers and manures

   i) On the comparative efficiency of certain fertilisers for sugarcane.

   ii) On the comparison of nitrophosphate manufactured by O.D.D.A. and P.E.C. processes at different levels and applied to sugarcane crop by different methods.

7. Studies in ripening

   Progress of ripening in sugarcane stalks of different varieties.

8. Miscellaneous

   i) Seedlings.
   ii) Preliminary test of seedling varieties 1961-batch.
   iii) Final test plot.
   iv) Trial of varieties.
   v) Live herbarium.

Agricultural Chemistry and Soil Science

1. Modus operandi of green manuring for sugarcane.
2. Comparative cumulative effects of manures and fertiliser on sugarcane crop and soils.
3. Effect of bulk density of soil on the growth of sugarcane.
4. Contribution of sub-soil in the nutrition of sugarcane.
5. Growing of cane on barren alkaline soils.
6. Effect of bacterial polysaccharides on soils.
7. Effect of Trace element sprays on sugarcane.

Physiology

1. Studies on the prevention of flowering.
2. Studies on germination.
3. Biochemical basis of resistance to red rot.

Agricultural Engineering

1. Study and improvement of agricultural implements at present used for sugarcane cultivation in different regions.
2. Designing and fabricating improved bullock-drawn and tractor-drawn implements and other machinery for sugarcane cultivation.
3. Devising ways and means of conserving irrigation water.
4. Mechanisation of sugarcane cultivation.
5. Collaborative conduct of long-term experiments on important cultural operations.

Mycology

1. Studies on nature of red rot resistance in sugarcane.
2. Assessment of comparative reaction of sugarcane varieties to red rot infection.
3. Comparative behaviour of varieties in relation to life cycle of cane to red rot infection.
4. Studies on technique of inoculation of canes for red rot.
5. Studies on the wilt of sugarcane in relation to red rot.
6. Assessment of comparative reaction of sugarcane varieties to smut infection.
7. Studies on the physiology of U. scitaminea.
8. Studies on the infection of sugarcane by smut fungus and development of an inoculation technique.
9. Studies on plant parasitic nematodes.
10. Training of research workers in techniques of plant nematology.

Entomology

1. Studies on the toxicity and persistence of different insecticides in relation to major sugarcane pests i) in relation to newly-hatched larvae of Chilotraea auricilia Ddgn., ii) in relation to grown-up larvae of C. auricilia at different levels of temperature and humidity.

2. Studies on some promising parasites of sugarcane pests: biology of Apanteles flavipes Cam. and Telenomus beneficiens Zhnt.

3. Study of methods for assessing pest incidence and population: incidence and population of stalk borer and top borer.

4. Classification and maintenance of sugarcane insect fauna.

5. Studies on biology and control of stalk borer, C. auricilia Ddgn.

6. Study of behaviour of new Co. varieties towards pest incidence.

7. Preparation of critical reviews of entomological work in and outside India and of survey maps relating to the distribution and the intensity of attack of different cane pests in India.

Publications

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17. Tewari, M.M. and Singh, Kishan, Chemical control of sugarcane rust, Ind. Jour. Sug. Res. & Dev., 6(3): 179-180 (1962).

APPENDIX

Equivalents in Metric, Indian and British Units

In the tables below, the equivalent of a given unit of a given system will be found in the column of the needed unit of the needed system, in the same line as the unitary figure of the given unit. Each comma occurring after a decimal stop stands for three zeros; thus 0.,038 stands for 0.000038. Equivalents involving a very large number of digits and not commonly needed have been omitted

Linear measurement

Inch		Foot		Yard		Mile		Centimetre		Metre		Kilometre
1	=	0.0833	=	0.0278	=	0.,016	=	2.54	=	0.0254	=	0.,025
12	=	1	=	0.333	=	0.,189	=	30.48	=	0.3048	=	0.,305
36	=	3	=	1	=	0.,568	=	91.44	=	0.9144	=	0.,914
63,360	=	5,280	=	1,760	=	1	=	-	=	1,609	=	1.61
0.3934	=	0.033	=	0.011	=	0.,006	=	1	=	0.01	=	0.,01
39.37	=	3.28	=	1.09	=	0.,621	=	100	=	1	=	0.,1
39,370	=	3,281	=	1,094	=	0.6214	=	10^5	=	1,000	=	1

Spatial measurement

Inch^2		Foot^2		Yard^2		Acre		Centimetre^2		Metre^2		Hectare
1	=	0.0069	=	0.,772	=	0.,,159	=	6.452	=	0.,655	=	0.,,065
144	=	1	=	0.111	=	0.,023	=	929.0	=	0.0929	=	0.,009
1,296	=	9	=	1	=	0.,207	=	8,361	=	0.836	=	0.,084
-	=	43,560	=	4,840	=	1	=	-	=	4,047	=	0.4051
0.1550	=	0.001	=	0.,12	=	-	=	1	=	0.,1	=	0.,,01
1,550	=	10.76	=	1.196	=	0.,247	=	10,000	=	1	=	0.,1
-	=	-	=	11,960	=	2.471	=	10^8	=	10,000	=	1

Volumetric measurement

Inch^3		Foot^3		Yard^3		Centimetre^3		Metre^3
1	=	0.,579	=	0.,0021	=	16.39	=	0.,016
1,728	=	1	=	0.037	=	28,317	=	0.0283
46,656	=	27	=	1	=	-	=	0.765
0.061	=	0.,035	=	-	=	1	=	0.,001
61,024	=	35.32	=	1.31	=	10^6	=	1

Measurement of capacity

Fluid ounce		Imperial gallon		Millilitre		Litre
1	=	0.0625	=	28.41	=	0.0284
160	=	1	=	4,546	=	4.546
0.0352	=	0.,22	=	1	=	0.001
35.2	=	0.22	=	1,000	=	1

Gravimetric measurement

Lb.		Ton		Seer		Maund		Kilogram		Quintal		(Metric) Tonne
1	=	0.,447	=	0.486	=	0.0121	=	0.454	=	0.0045	=	0.,454
2,240	=	1	=	1,089	=	27.2	=	1016	=	10.16	=	1.016
2.057	=	0.,918	=	1	=	0.025	=	0.933	=	0.0093	=	0.,933
82.29	=	0.0367	=	40	=	1	=	37.32	=	0.373	=	0.0373
2.204	=	0.,984	=	1.072	=	0.027	=	1	=	0.01	=	0.001
220.4	=	0.098	=	107.2	=	2.68	=	100	=	1	=	0.1
2,204	=	0.984	=	1,072	=	26.79	=	1,000	=	10	=	1

Measurement of rate as between distance and capacity

Mile. per imperial gallon		Kilometre per litre
1	=	0.354
2.825	=	1

Measurement of rate as between area and weight

Lb.per acre		Ton per acre		Maund per acre		Kilogram per hectare		Quintal per hectare		Metric tonne per hectare
1	=	0.,45	=	0.0122	=	1.12	=	0.0112	=	0.0011
2240	=	1	=	27.22	=	2,511	=	25.11	=	2.511
82.29	=	0.037	=	1	=	92.29	=	0.923	=	0.092
0.892	=	0.,398	=	0.011	=	1	=	0.01	=	0.001
89.22	=	0.039	=	1.08	=	100	=	1	=	0.1
892.2	=	0.398	=	10.84	=	1,000	=	10	=	1

Measurement of rate as between capacity and area

Fluid ounce per foot^2		Imperial gallon per acre		Millilitre per metre^2		Litre per hectare
1	=	272.25	=	305.84	=	3,058.4
0.0037	=	1	=	1.12	=	11.23
0.0033	=	0.89	=	1	=	10
0.,33	=	0.089	=	0.1	=	1

Measurement of dilution by capacity

Fluid ounce per imperial gallon		Millilitre per litre
1	=	62.5
0.16	=	1

Measurement of dilution of weight by capacity

Lb.per imperial gallon		Gram per litre		Kilogram per litre
1	=	99.78	=	0.0998
0.01	=	1	=	0.001
10.02	=	1,000	=	1

Measurement of dilution by weight

Seer per maund		Lb.per ton		Gram per kilogram		Kilogram per quintal
1	=	56	=	25	=	2.5
0.018	=	1	=	0.446	=	0.045
0.04	=	2.24	=	1	=	0.1
0.4	=	22.4	=	10	=	1

All India Co-ordinated Scheme for the Investigations and Control of Rust Disease of Sugarcane - Indian Institute of Sugarcane Research, Lucknow.

Annual Report for 1961-62

(Kishan Singh : Mycologist-incharge)

Objective.- Studies on the rust disease of sugarcane with special reference to its control.

Finance and details of implementation.- The Scheme was wholly financed by the Indian Central Sugarcane Committee. The budget grant of the Scheme under report was Rs.14,000.00, the revised estimate Rs.11,200.00 and the total expenditure Rs.11,773.00.

Staff.- The following sanctioned staff in the scheme continued to be working during 1961-62.

Assistant Mycologist	(Class II)	One
Fieldmen	(Rs.80-110)	Two
Malies	(Rs.75-85)	Two

Shri M.M. Tiwari was the Assistant Mycologist from November 21, 1959. The investigations were carried out under the guidance of Dr.Kishan Singh, Mycologist.

Technical programme of work 1961-62

1. Testing the efficacy of fungicides for direct control of rust.

2. Standardisation of technique for adult resistance.

3. Search for collateral hosts.

4. Screening of varieties for rust resistance.

Non-technical summary.- Studies on chemical control of sugarcane rust could not be conducted during this season as the natural infection of rust was negligibly low. Three techniques for inoculation for adult resistance tests in the field were tried with a view to standardising a technique; one of these, called the Cellotape technique proved to be better than the rest; but the infection in this also was poor as compared to the cut-leaf technique in the laboratory. Saccharum spontaneum clone (SES 66) was found to be capable of taking infection of rust from Co.419. This suggests that some clones of Saccharum spontaneum may act as collateral hosts of sugarcane rust. Co.312, Co.419, Co.453, Co.933, Co.S.443, Co.S.510 in the field experiments and Co.312, Co.419, Co.421, Co.453, Co.933, Co.S.443, Co.S.510 and Poovan in the laboratory experiments proved to be susceptible. Rust cultures from Lucknow and Coimbatore could be successfully maintained on leaf-pieces in the laboratory throughout the year by the technique perfected at this Institute.

Besides the items of the technical programme physiologic specialisation and the histopathology of sugarcane rust were studied. Physiologic specialisation has been observed in the sugarcane rust organism for the first time.

Detailed Report

1. Testing the efficacy of fungicides for direct control of rust.- Following the past two years of experiments on the chemical control of sugarcane rust a survey was conducted in February, 1962 in the Balrampur area for finding pockets of rust. The natural incidence of rust however, was low in the area, and the control experiments therefore could not be conducted.

2. Standardisation of technique for adult resistance.- With a view to developing a technique for adult resistance trials in the field, three techniques were attempted.

(a) The Cellotape technique.- A thick suspension of freshly-collected uredospores of sugarcane rust was made in tap water. A drop of the suspension was placed on the under-surface of the leaf together with a small piece of moist cotton on the side of the drop. The spore drop and the cotton were held in contact with the leaf with a wide cellotape with the edges of the tape firmly stuck to the leaf surface. The test plants were sprayed with fine spray of water every half-an-hour throughout the day and the next day.

(b) Diseased leaf-piece technique.- This technique has been reported to be successful in Cuddalore. In this, small pieces of infected leaves are stuck to the lower surface of a healthy test leaf. This technique did not give infection in any of the varieties experimented with.

(c) Polyethylene bag technique.- A uredospore suspension in tap water was sprayed on the leaves of test plants. Large polyethylene film bags were then slipped over the clumps of inoculated plants with a view to maintaining a constant high humidity. These were maintained in this condition for two days. However in none of the cases was any infection recorded. Another modification of this technique is being experimented within 1962-63 season.

It appears that the cellotape technique alone was successful for the infection of leaves; however, even in this the infection was low.

3. Collateral host studies.- Rust from Co.419 (Lucknow) was inoculated on the leaves of Saccharum spontaneum clones SES 2, SES 6, SES 13, SES 32B SES 66, SES 77, IMP 970, IMP 1182 obtained from the Sugarcane Breeding Institute and Erianthus fulvus collected in the Rust Scheme from Himachal Pradesh. Sugarcane rust produced normal pustules on the leaves of SES 66, but failed to infect the rest of the clones. On the leaves of E. fulvus the infection caused a resistant reaction.

This is the first record of a possible collateral host of the sugarcane rust organism in India.

Erianthus munja rust was inoculated on the leaves of sugarcane varieties Co.527, Co.605, Co.617, Co.619, Co.684, Co.792, Co.798, Co.853, Co.899, Co.933, Co.997, Co.K.32, Co.L.29, Co.1111, Co.1209, Co.S.416, Co.S.443, Co.S.510, Co.S.514 and Poovan (a variety of S. officinarum from south India). Rust pustules did not develop on any of the varieties; however, a resistant reaction was observed in the case of Co.S.510 and Poovan. Rust occurring in nature on Cyperus rotundus failed to infect the leaves of Co.S.510 and Co.419.

4. Adult resistance trial.- (i) In the laboratory - the leaves of Co.290, Co.312, Co.313, Co.419, Co.421, Co.449, Co.453, Co.469, Co.475, Co.513, Co.527, Co.605, Co.617, Co.619, Co.684, Co.792, Co.798, Co.853, Co.899, Co.933, Co.975, Co.997, Co.1111, Co.1209, Co.K.32, Co.L.29, Co.S.416, Co.S.443, Co.S.510, Co.S.514, Co.S.515, B.O.3, B.O.10, B.O.11, B.O.13, B.O.14, B.O.17, B.O.21, Red Mauritius and Poovan were inoculated by the cut-leaf technique in the laboratory. The inoculations were done on the 2nd and 21st of November, 6th, 7th, 11th, 15th, 19th and 29th December, 1961. In this Co.312, Co.419, Co.421, Co.453, Co.933, Co.S.443, Co.S.510 and Poovan were found to be susceptible to sugarcane rust (Lucknow collection). Co.290 and Co.475 gave 'resistant reaction'. The 'resistant reaction' of the leaves was characterised by the formation of minute red spots at the points of inoculation. A histological study of these red spots showed that the host cells where the uredospore germ tube came in contact were filled with reddish substance. The individual cells were not visible in this reddened zone. The red spots did not later develop into pustules. This kind of host response to rust inoculation was tentatively named as 'resistant reaction'.

(ii) In the field experiment, the 59 varieties, mentioned earlier except Poovan, were inoculated by the 3 techniques, viz. Cellotape, diseased leaf piece and Polyethylene bag techniques.

The field inoculations by the first two techniques were done on 24th and 25th of November, 7th, 11th, 15th of December, 2nd, 9th and 10th of January 1962. Co.419, Co.617, Co.899, Co.933, Co.S.443 and Co.S.510 got the infection; in all these rust pustules were formed at the sites of inoculation. 'Resistant reaction' was noticed on the leaves of Co.290 and Co.313 inoculated by the cellotape technique.

5. Maintenance and multiplication of rust cultures.- Rust appeared in nature on Co.419 at the Institute farm again this year and was recorded on 16th October, 1961. It was recorded for the first time on Co.S.510 on 8th December, 1961 though in traces. A culture of this fungus was maintained on Co.S.510 by the cut-leaf technique through 52 generations. Cultures were also maintained on potted plants of Co.S.510 in plant incubation boxes. The cultures of Co.475 rust from the Sugarcane Breeding Institute, Coimbatore were also maintained successfully on Co.475 and Co.S.510 by the cut-leaf technique.

6. Studies on physiologic specialisation in sugarcane rust.- With a view to establishing cultures of rust from different varieties and localities, rust infecting Co.475, P.12687, P.12771, P.12346 and P.13001 at the Sugarcane Breeding Institute, Coimbatore was collected, and inoculated on the leaves of Co.475, Co.419 and Co.S.510 at this Institute. Only rust from Co.475 could be established and that on Co.475. The studies on physiologic specialisation were conducted in the laboratory with rust on Co.419 (Lucknow), and rust from Coimbatore using the cut-leaf technique. The observations (table 1) show that rust occurring in nature on Co.475 at Coimbatore could infect the leaves of Co.475 and Co.S.510, but not the leaves of Co.419 although this is a susceptible variety at Lucknow. Similarly, rust from Co.419 at Lucknow could infect the leaves of Co.419 and Co.S.510, but not those of Co.475; a resistant reaction was obtained in this latter variety. This indicates the organism causing rust on Co.475 at Coimbatore and the one occurring on Co.419 at Lucknow though morphologically alike differ in their parasitic behaviour. This indicates the presence of physiologic specialisation in the sugarcane rust fungus and the existence of at least two races of the fungus. This is a first record.

Table 1

Reaction of sugarcane varieties to two rust cultures Co.419 and Co.475 rust

Inoculum	Host varieties and reaction		
	Co.475	Co.419	Co.S.510
Co.475 (Coimbatore)	+	-	+
Co.419 (Lucknow)	0	+	+

+ = normal rust pustules
0 = Resistant reaction
- = no reaction

7. Histopathological studies of sugarcane rust.- With a view to studying the stages of infection upto the formation of uredo and teleuto pustules in a susceptible variety leaves of Co.S.510 were inoculated with sugarcane rust collected at different stages, viz. fleck formation, beginning of the pustule-formation and bursting of the uredo-pustule and was preserved in formalin-acetic-alcohol. Hand sections were then cut of this material stained with cotton blue and permanent mounts were prepared. The preparations show that the initial infection takes place through the stomatal opening, and spreads through the lower parenchymatous cells; ultimately the epidermal layer bursts and the uredospore

mass comes out. The same sorus develops teleutospores after the uredial stage has ceased.

Leaves showing resistant reaction were also studied. Erianthus fulvus leaves inoculated with Co.419 rust produced a resistant reaction. Similarly E. munja rust induces a resistant reaction on the leaves of Co.S.510 instead of forming the normal pustule. The affected leaves of Co.S.510 and E. fulvus were cut, permanent mounts were prepared and studied under microscope. The reddening was found to be due to the secretion of a gum-like substance from the affected cells (mainly parenchymatous cells) just below the germinating uredospore. Fungus hyphae however could not be traced either in the cells or in the intercellular spaces.

Technical Programme for 1962-63

1. Testing the efficacy of fungicides for control of rust.

2. Standardisation of technique for adult resistance tests.

3. Search for collateral hosts.

4. Screening of varieties for rust resistance.

Publications

1. Tiwari, M.M. and Kishan Singh (1962) Chemical control of sugarcane rust, Indian J. Sugarcane Res. & Dev. 6 (3) p.179-180.

2. Singh, Kishan and M.M. Tiwari (1962) Maintenance of rust cultures. Ind. J. Sugarcane Res. & Dev. 6 (4) p.241-242.

Entomological Outposts Scheme

Indian Institute of Sugarcane Research, Lucknow.

Annual Report for 1961-62

(A.N. Kalra : Entomologist-in-Charge)

Objective

The aim of the Entomological Outposts Scheme is to survey the different areas for the occurrence of sugarcane pests, to study the biology of the major pests, and to gather information on the influence of weather and climatic conditions on their incidence and population.

Studies of this type have been in progress for the past many years in the Punjab, Uttar Pradesh, Bihar, West Bengal, Andhra Pradesh, Bombay (now Maharashtra) and Madras. But in certain other States e.g. Rajasthan, Madhya Pradesh, Assam and Orissa, such work had not been taken up till 1958. The Indian Central Sugarcane Committee therefore sanctioned in 1958, the establishment of 5 Entomological Outposts, one each for Rajasthan, Madhya Pradesh, Orissa, Assam and the Tanjore area of Madras.

Finance and details of implementation

The Scheme was implemented in 1959-60 and 4 Entomological Outposts, viz. Sriganganagar (Rajasthan), Sehore (Madhya Pradesh), Koothanallur in Tanjore district (Madras) and Rayagada (Orissa) were established under the Indian Institute of Sugarcane Research, Lucknow. The establishment of the 5th Outpost in Assam has been in abeyance at first due to the inability of the selected candidates to join there, and now due to reduction in the sanctioned budget of the Scheme during the 3rd Plan.

The total budget sanctioned for the Scheme for 1961-62 was Rs.75,000. The expenditure during the year was Rs.57,660. The Scheme is at present sanctioned upto 28th February, 1966. It is financed wholly by the Indian Central Sugarcane Committee.

Staff

The staff at each Outpost comprises one Senior Research Assistant, one Research Assistant, one Field Attendant and one Laboratory Attendant. The names of the personnel on the Scheme in 1961-62 are given below.

Sriganganagar

Senior Research Assistant	...	Shri Sunil Kumar
Research Assistant	...	Shri N.C. Sharma

Sehore

Senior Research Assistant	...	Shri A.K. Mehrotra
Research Assistant	...	Shri D.N. Shukla (joined on 3rd August 1961)

Koothanallur

Senior Research Assistant	...	Shri H. David
Research Assistant	...	Shri K. Anantharayana

Rayagada

Senior Research Assistant	...	Shri C.P. Dutta
Research Assistant	...	Shri D.K. Banerji

The technical guidance to the staff was provided by the Entomologist, Indian Institute of Sugarcane Research, who is the Officer-in-Charge of the Scheme.

Technical programme of work 1961-62

1. Influence of individual weather conditions, (cloudiness, rain, humidity etc.) and general climatic conditions, on the incidence and population of borers, Pyrilla and white-fly infesting sugarcane.

2. Biology of sugarcane pests.

3. Survey of cane pests.

4. Collection of insect fauna visiting sugarcane during the crop season.

Non-technical summary

As in the previous years, the shoot borer, Chilotraea infuscatellus Snell. remained active at Sriganganagar from April to October, but it also damaged the crop as cane borer in the monsoon and postmonsoon periods. The root borer, Emmalocera depressella Swinh. which was serious at Sriganganagar and Sehore, flourished under the high maximum temperatures and the moderate to high relative humidities. Heavy attack of pink borer, Sesamia inferens Wlk. was met with in the premonsoon period at Sriganganagar and Sehore, and that of the mealy bug, Saccharicoccus sacchari Ckll. at Rayagada and Sriganganagar till the monsoon and postmonsoon periods respectively. The internode borer, Proceras indicus Kapur was serious at Koothanallur, as usual, from October to February. The attack of Pyrilla perpusilla Wlk. and white-fly, Aleurolobus barodensis Mask. was negligible at all the four Outposts.

The top borer remained active from about mid-February to mid-October and passed through 5 broods during the year both at Sriganganagar and Sehore. The activity of shoot borer also continued till October at Sriganganagar, but at Sehore it declined after August. The pink borer completed 4 life cycles from beginning of February to mid-August at Sehore, while the internode borer passed through six broods under laboratory conditions at Koothanallur.

The sugarcane crop was surveyed for the major pests in most of the important cane-growing areas of Rajasthan, Madhya Pradesh and Orissa and in Tanjore, Tiruchirappalli, Salem, South Arcot and Chingleput districts of Madras. Incidence of a beetle grub pest, Lachnosterna sp. in Hospet area of Mysore State was also recorded.

Rearing of Isotima javensis Bow. and Tetrastichus israeli Mani and Kurian, originally obtained from Pugalur, was taken up in the laboratory at Koothanallur with a view to releasing the two parasites in the fields (in Tanjore area), against top borer and internode borer respectively. I. javensis was later found to have established itself in the released fields. In case of T. israeli only stray cases of parasitisation were met with in the fields where releases were made.

In the trials on chemical control of termites at Rayagada, aldrin dust and emulsion gave better results than the rest of the insecticides tried, viz. gamma BHC, chlordane, dieldrin and heptachlor. In another experiment it was observed that the attack of termites to buds, setts and shoots could be reduced by planting nursery-raised germinated setts.

Detailed report

1. Influence of individual weather conditions and general climatic conditions on the population of borers, Pyrilla and white-fly.

Observations on different pests were recorded at all the 4 Outposts according to the standard method followed under the co-ordinated Insect Pests Scheme. The observations and meteorological data are

are given in table 1 and figures 1 to 4.

Table 1

Population and incidence of various sugarcane pests in relation to temperature, humidity and rainfall

ne of the pest	Outpost	Va-ri-ety	Period of maximum activity Period of maximum activity	Max * popl. (lar-vae and pupae), 000 per hect-are	Max temp °C (fort-night-ly aver-age)	Min temp °C (fort-night-ly aver-age)	Mean R.H (per cent)	Rain-fall in mm
p borer, nivella	Srigan'r	A	Early-Aug. to end-Nov.	70.2 (31-85)	25-38	9-27	46-72	88
	Sehore	B	Mid-May to mid-Oct.	16.5 (8-31)	26-40	13-26	46-72	1822
	Rayagada	B	No attack in exptl. crop	-	-	-	-	-
	Kthnlur.	B	Early-July to end-Sept.	5.6 (2-7)	34-36	20-25	49-62	225
oot borer, infusca-llus	Srigan'r	B	Mid-July to mid-Sept.	29.2 (19-51)	36-38	26-27	53-72	204
	Sehore	B	Mid-April to end-May	2.8 (9-10)	37-40	19-26	46-60	1
	Rayagada	B	Mid-April to end-May	16.3 (10-29)	38-41	-	59-66	291
	Kthnlur.	B	Early-May to 3rd wk.of July	22.9 (18-39)	35-39	24-28	60-67	93
oot borer, depress-lla	Srigan'r	B	Mid-June to mid-August	20.8 (5-37)	37-43	23-30	31-66	123
	Sehore	B	Early-June to mid-August	16.6 (4-29)	20-36	23-25	60-72	706
	Rayagada	B	Early-June to end-July	16.3 (4-7)	29-35	-	66-87	530
	Kthnlur.		No attack in exptl. crop	-	-	-	-	-
nternode borer, . indicus	Srigan'r	-	No attack in exptl. crop	-	-	-	-	-
	Sehore	-	No attack in exptl. crop	-	-	-	-	-
	Rayagada	B	Month of July	Low	29-32	-	82-87	245
	Kthnlur.	B	Early-Dec. to 3rd wk.of May	6.8 (12-35)	29-37	19-21	68-85	182
Pink borer, S. inferens	Srigan'r	A	Mid-June to end-July	3.5 (1-4)	37-43	26-27	53-65	116
	Sehore	B	Mid-April to end-June	5.5 (9-10)	35-40	19-26	40-55	69
	Rayagada		No attack in exptl. crop	-	-	-	-	-
	Kthnlur.		No attack in exptl. crop	-	-	-	-	-
Pyrilla	Srigan'r	A	Mid-Aug. to end-Sept.	Low	36-38	26-26	65-72	81
	Sehore		No attack in exptl. crop	-	-	-	-	-
	Rayagada		No attack in exptl. crop	-	-	-	-	-
	Kthnlur.		No attack in exptl. crop	-	-	-	-	-

A : Co 312; B : Co 419

*Incidence values shown within brackets.

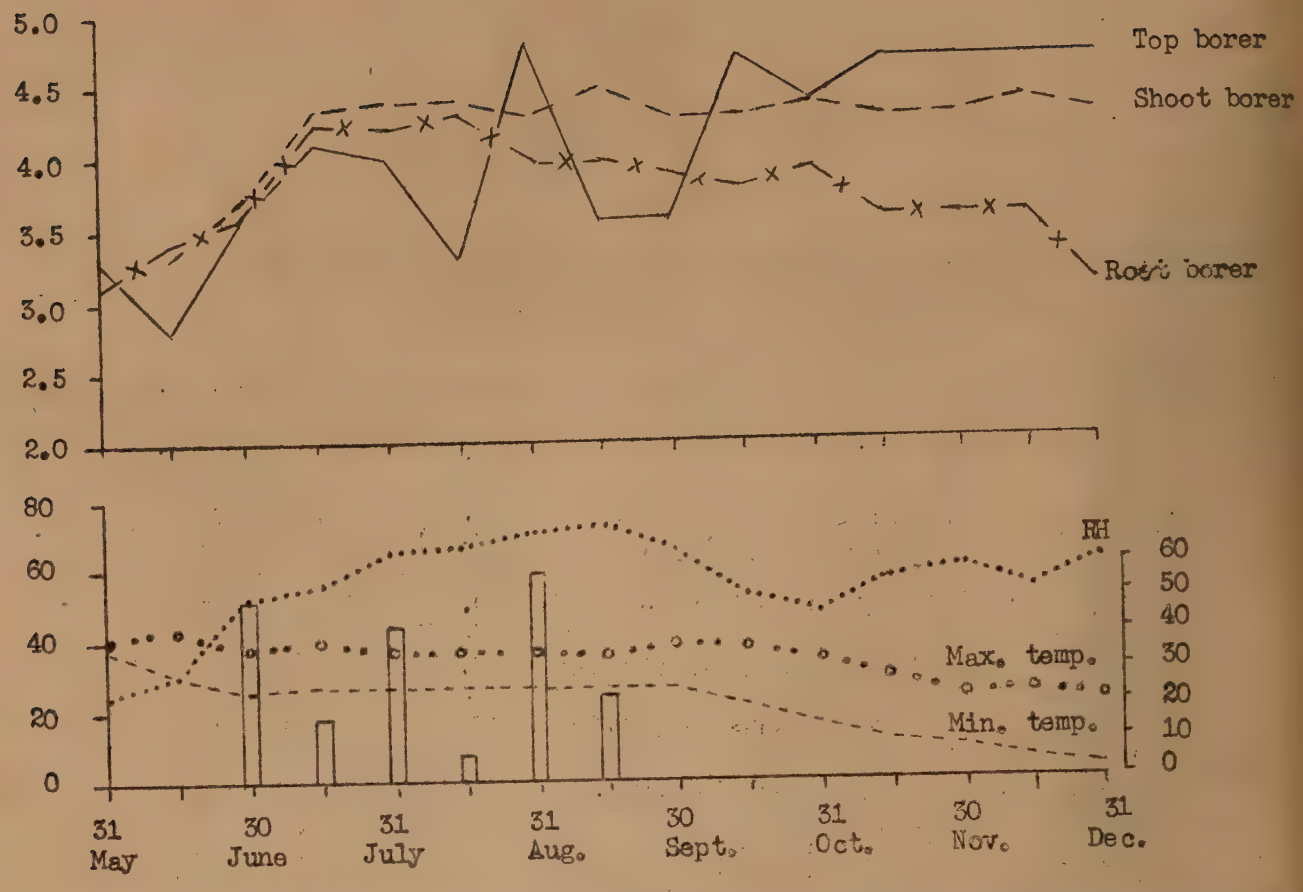

Fig.1- Climatic conditions in relation to borer population (Sriganganagar 1961-62). Ordinates : Log e (Number of larvae and pupae per ha), maximum and minimum temperature in °C, per cent RH and rainfall in mm. Abscissae : Dates of observation.

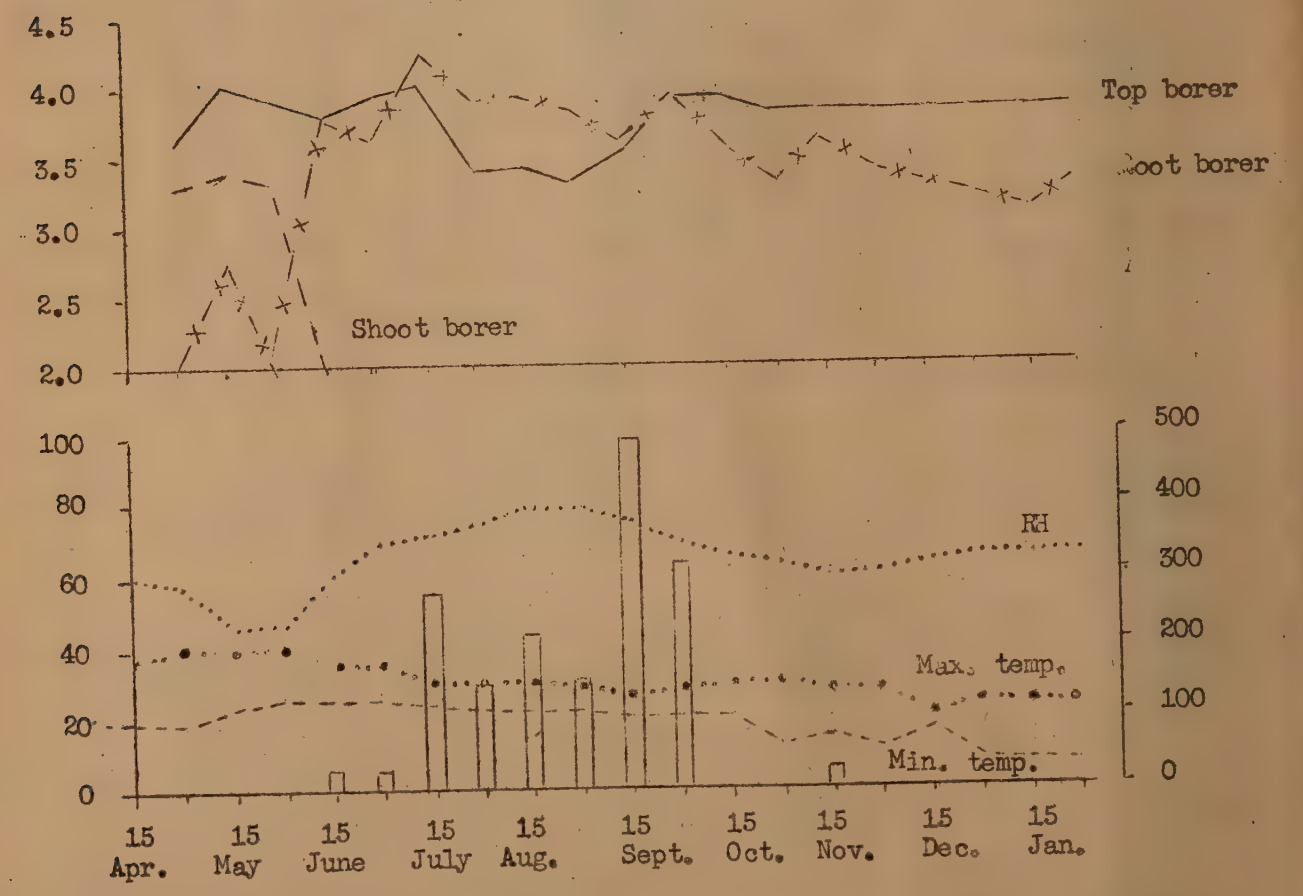

Fig.2- Climatic conditions in relation to borer population (Sehore 1961-62). Ordinates : Log e (Number of larvae and pupae per ha), maximum and minimum temperature in °C, per cent RH and rainfall in mm. Abscissae : Dates of observation.

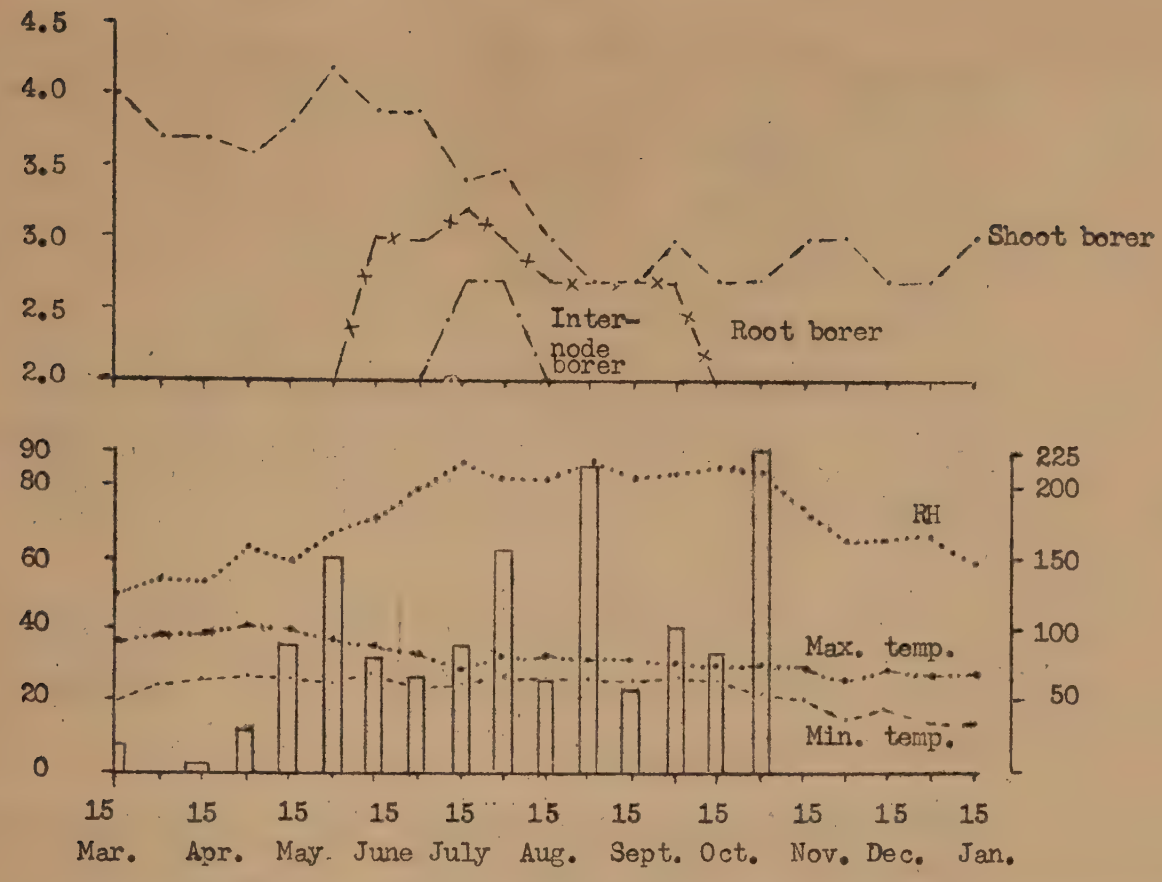

Fig.3- Climatic conditions in relation to borer population (Rayagada 1961-62). Ordinates : Log e (Number of larvae and pupae per ha), maximum and minimum temperatures in °C and rainfall in mm. Abscissa:Dates of observation.

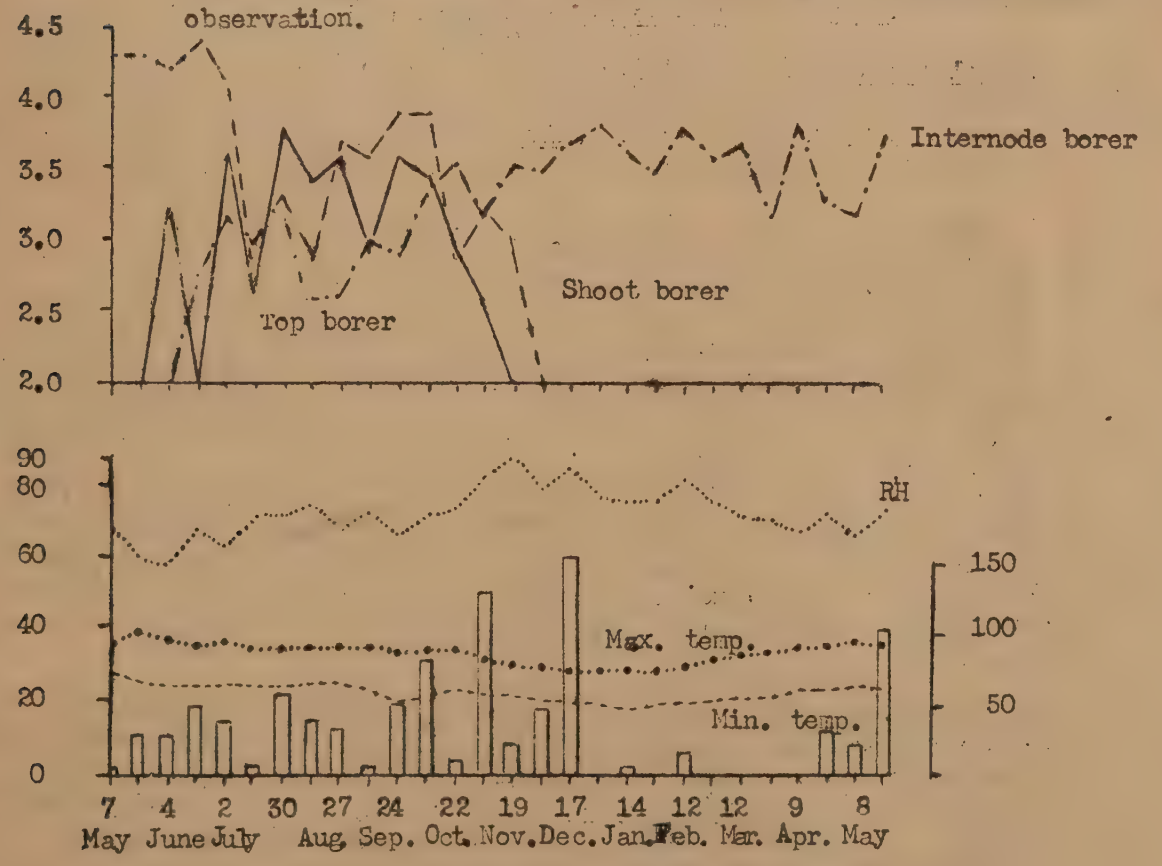

Fig.4- Climatic conditions in relation to borer population (Koothanallur 1961-62). Ordinates : Log e (Number of larvae and pupae per ha), per cent RH, maximum and minimum temperatures in °C and rainfall in mm. Abscissae: Dates of observation.

As in the previous years, the shoot borer, Chilotraea infuscatellus Snell. was active at Sriganganagar till end-October; it damaged the crop as shoot borer in premonsoon season and as cane borer thereafter. The root borer, Emmalocera depresella Swinh. was more serious than in previous years both at Sehore and Sriganganagar, its maximum activity being in July and August respectively. Fairly high maximum temperatures with moderate to high relative humidity (RH) appeared to favour the multiplication of this pest. The top borer, S.nivella, usually serious in monsoon and post-monsoon, showed fairly high populations at Sehore in early May also, probably due to higher RH there in April. At Rayagada, top borer incidence was negligible; the causes of this are under study. Heavy attack of pink borer, Sesamia inferens Wlk. was met with at Sriganganagar and Sehore in the premonsoon period, declining later. Mealy bug, Saccharicoccus sacchari Ckll. was fairly serious in the premonsoon and monsoon periods at Rayagada, and in the monsoon and post-monsoon periods at Sriganganagar under conditions of high maximum temperature and moderate relative humidity.

The internode borer, Proceras indicus Kapur which was met with at Koothanallur only, became more serious as usual with the start of rains in October and damaged the crop till harvest. Attack of Pyrilla and whitefly, Aleurolobus barodensis Mask. was negligible at all the Outposts.

2. Biology of sugarcane pests

Sriganganagar.- Top borer, S.nivella completed 5 generations during the year, starting end-February, early May, end-June, 2nd week of August and end September, respectively; their durations were about 10, 9, 7, 7, and 23 weeks respectively, with slight over-lappings. The 5th brood larvae hibernated from mid-October to mid-February and moths began to emerge in end-February.

Shoot borer, C.infuscatellus also completed 5 generations, starting early March, early May, early July, 2nd week of August and 3rd week of September, respectively. The 5th brood larvae hibernated from mid-October to end-February; the durations were about 9,,9, 6, 6 and 24 weeks, respectively. Between March and September, the durations of egg, larval and pupal stages were 6, 19-36 and 6-8 days respectively.

Sehore.- Top borer, S.nivella passed through 5 broods starting mid-February, 3rd wk. of April, early June, end-July and 3rd wk. of September, respectively. There was a slight over-lapping of broods. The durations of the broods were about 9, 7-8, 8-9, 9, and 22 weeks respectively. The larvae of the 5th brood hibernated from mid-October to end-January. The durations of egg, larvae and pupal stages were 6-10, 29-40 and 6 - 12 days respectively during mid-February to end-September.

Shoot borer, C.infuscatellus also completed 5 broods during the year, starting from early February, end-March, mid-May, early-July and 3rd wk. of August; their durations were about 8-9, 7-8, 7, 6-7 and 24 weeks, respectively. The 5th brood larvae hibernated from early October till end-January. The durations of egg, larval and pupal stages were 4-7, 28-35, 6-10 days. respectively in the period February to September.

The pink borer, S.inferens completed 4 life-cycles from early February to mid-August, starting from early February, early April, 3rd wk. of May and end-June, respectively with slight overlappings. The durations of egg, larval and pupal stages of the 4 broods were 5-6, 28-40, and 6-12 days respectively.

Rayagada .- Shoot borer, C.infuscatellus.- The biology of this pest was studied for the first 3 broods. The broods started in 2nd wk.of February, 2nd wk.of April and in 3rd wk.of June respectively. The durations of egg, larval and pupal stages were 4-5, 25 to 39 and 6-8 days respectively.

Koothanallur.- The internode borer, P.indicus completed 6 broods during the year in the laboratory, starting 2nd wk. of May, early July, early August, early November, 3rd wk. of January and 3rd wk. of March respectively. Under field conditions, there was considerable overlapping of broods. The durations of egg, larval and pupal stages in the laboratory were 5-6 days, 36-56 days and 9-12 days respectively. Moths emerged in the early morning hours and mated soon after. The preoviposition period was 2 to 3 days. The males generally died soon after copulation. The adults lived for 1-7 days in captivity.

Oviposition .- The females lay eggs generally in linear rows on the upper or lower surface of the leaves or on the outer side of leaf sheaths, a few to as many as 98 eggs per cluster. Unfertilised eggs when laid soon shrivel up. The incubation period is 5-6 days.

Larva .- The freshly emerged larva is light orange in colour with a black head and prominent thoracic shield. The larvae are very active in the initial stages and feed gregariously sheltering underneath the leaf sheath and feeding by scraping the sheath. Subsequently they burrow into the cane and feed individually.

The larvae are voracious feeders, they eject frass outside the larval burrows. The larval stage varied from 36 to 56 days during the different seasons.

Moulting.- The larva moulted seven times. The first moult started by the 3rd, 4th or 5th day. Before each moulting, the larva became inactive; thus cuticle on the dorsal side in the post-cephalic region split, the split extending posteriorly. Meanwhile, the outer covering of the cephalic shield was cast off and the larva wriggles to complete the moulting. The time taken was about 45 minutes in most cases, sometimes much longer. The newly-moulted larva became active again.

Pupae .- The larva usually constructs a white silken nest in the leaf-sheath and pupates inside it after the 7th moult. The newly-formed pupa is light brown, with faint larval stripes, and later it turns dark brown.

3. Survey of sugarcane pests

Rajasthan.- The survey of the important cane growing areas was continued (table 2). Top borer incidence was heavy (40 to 80 per cent) in Sriganganagar, Udaipur, Bundi, Chittorgarh, Jaipur and Bharatpur. Shoot borer attack was serious (20 to 72 per cent) in Sriganganagar and Udaipur districts. In Sriganganagar area it damaged the crop as cane borer also in the monsoon and postmonsoon periods. Incidence of root borer was fairly high in some areas of Sriganganagar and Udaipur districts. Heavy attack of pink borer was recorded at Boon in Udaipur district, Nandor in Dungarpur district and at Banswara in Banswara district. Termite damage was fairly serious at most of the places in Sriganganagar and Udaipur districts and at Lodha in Banswara district. Attack of Pyrilla was met with in Udaipur area only. Stray cases of attack of Gurdaspur borer, Bissetia steniellus Hmpsn. were recorded at the Agricultural Farm, Sriganganagar. Whitefly, mealybug, lygaeid bug (Macropes excavatus Dist.) and sugarcane mite (Paratetranychus indicus Hirst) occurred only in a mild form in some localities. Attack of white grub was recorded in Udaipur and Sriganganagar districts.

Madhya Pradesh .- Heavy top borer attack (25 to 90 per cent) was recorded in almost all the areas surveyed (table 3). Only in Guna and Bastar districts, the incidence was comparatively low. Shoot borer was serious in Sehore, Gwalior and Guna districts and at Kota in Sheopuri district. Fairly heavy attack of root borer was met with at Sehore and in certain areas of Gwalior district, and of pink borer in Sehore, Mandsaur, Ratlam, Ujjain and Shajapur districts. Incidence of termites, whitefly, mealybug and lygaeid bug was negligible. Pyrilla was serious at Sehore only.

Table 2

Survey of sugarcane pests (Rajasthan)

Locality	Top borer*	Shoot borer*	Root borer*	Pink borer*	Termite*	Pyrilla**	White-fly+	Mealy-bug++	Lygaeid bug++
Sriganganagar district									
Hanumangarh	48.1	31.7	7.1	nil	6.0	nil	5	nil	nil
Suratgarh	72.0	53.0	2.2	"	nil	"	7	"	"
Anupgarh	83.3	72.6	2.1	"	4.6	"	nil	"	"
Srivijainagar	63.5	49.3	0.3	"	1.5	"	"	"	"
Padampur	73.4	64.2	18.0	"	18.0	"	"	"	"
Raisinghnagar	74.5	51.0	6.3	"	10.2	"	"	"	"
Srikaranpur	69.9	53.7	3.7	"	3.1	"	3	"	"
Dalpatsinghpur	68.3	69.0	7.7	"	17.8	"	4	"	"
Sriganganagar	77.2	36.7	11.1	"	15.0	"	9	"	"
Udaipur district									
Lukhhali (Girva)	36.1	20.1	10.7	0.3	12.9	62	nil	"	"
Bhona (Girva)	32.6	28.4	5.9	nil	8.5	49	"	"	"
Rajnagar (Rajsumang)	38.0	25.5	22.2	"	26.5	15	"	"	"
Sanwad(Rajsumang)	23.4	21.2	10.6	"	19.6	21	"	"	"
Kelwar(Kumbhagarh)	25.4	28.5	21.2	0.3	15.2	5	"	"	"
Charbhuja (Kumbhagarh)	25.6	25.5	3.9	nil	13.5	57	"	"	"
Sallar(Nadward)	26.5	25.8	10.0	"	16.7	nil	"	"	"
Boon(Bhopalsagar)	76.7	38.9	12.8	50.0	19.6	54	"	"	"
Mavoli (Mavoli)	29.0	33.9	7.3	nil	15.4	18	"	"	"
Kareva(Bhopalsagar)	21.8	nil	4.2	5.4	3.5	T	"	19	"
Devali (Girva)	26.6	"	3.4	nil	nil	4	2	9	"
Pullar (Girva)	25.8	"	1.3	9.9	4.5	10	nil	12	"
Daroli	24.4	"	0.9	3.0	2.7	1	"	1	"
Dungarpur district									
Dungarpur	2.5	0.8	0.4	3.0	2.1	2	"	12	"
Nandor	15.4	nil	3.9	79.6	3.8	nil	8	22	"
Banswara district									
Lodha	12.1	"	6.0	4.4	17.9	"	nil	5	"
Banswara	12.0	"	2.4	58.1	2.5	"	2	10	"
Kota district									
Barkhera(Ladpura)	2.4	1.8	nil	nil	nil	"	nil	3	"
Kunari farm	15.5	4.8	0.0	2.3	"	"	"	nil	"
Tator (Ladpura)	1.5	7.7	nil	nil	"	"	"	"	"
Arjunpura	4.6	3.8	"	"	"	"	10	13	"
Jhalawar district									
Chandkheri(Khanpur)	4.7	4.0	0.4	nil	0.8	nil	11	12	nil
Bundi district									
Jamutpura(Tahera)	66.5	1.8	nil	"	nil	"	8	nil	"
Bansi(Nainwan)	64.3	7.3	"	"	"	"	5	6	"
Balrampur farm (Hindohi)	33.9	15.3	0.5	"	"	T	nil	nil	"

Locality	Top borer*	Shoot borer*	Root borer*	Pink borer*	Termite*	Pyrilla**	White-fly+	Mealy-bug++	Lygaeid bug++
Jaipur district									
Durgapur farm	40.5	3.7	nil	nil	nil	T	nil	nil	nil
Nawranijika (Ramgarh)	30.1	2.4	0.8	"	3.8	3	2	"	"
Bharatpur district									
Govt.Seed Farm Dawar	12.5	15.0	2.5	"	2.5	nil	3	35	14
Kureh(Bharatpur)	28.7	5.3	3.5	"	3.3	"	2	8	8
Santra(")	25.8	6.1	3.8	"	6.1	"	nil	17	7
Bhematpura (Bayana)	30.7	2.8	3.7	"	1.5	"	"	1	nil
Rotikera(Bayana)	59.8	1.9	0.7	"	1.1	2	2	14	"
Sawaimadhopur district									
Jangla	6.4	8.0	nil	"	3.4	1	1	2	"
Ajmer district									
Kanapar(Pisagan)	30.8	3.2	3.7	"	4.1	2	nil	3	"
Bhilwara district									
Malan(Bhilwara)	15.4	6.4	5.0	"	3.3	nil	"	nil	"
Devasadan farm (Bhilwara)	24.8	5.9	2.9	"	4.1	"	9	25	8
Jaysmalia (Bhilwara)	28.5	6.4	3.2	"	5.9	"	3	28	nil
Mandal	34.8	3.3	3.3	"	5.3	"	nil	1	"
Chitorgarh district									
Kaota(Kapasan)	41.5	4.4	3.9	"	2.6	"	"	17	4
Sambhalpura (Kapasan)	76.5	6.4	4.3	"	8.2	"	1	nil	nil
Mungana(Kapasan)	22.4	nil	2.6	13.9	5.2	2	nil	6	"

* Per cent incidence
** Population of adults and nymphs per leaf
\+ Population of nymphs and puparia per cm^2 leaf area
++ Population per shoot/cane

Orissa.- Attack of top borer was low in the State as a whole except Sambalpur and Puri districts where it ranged from about 15 to 22 per cent (table 4)..Shoot borer occurred as a serious pest in all the areas surveyed. Its incidence was as high as about 30 per cent at Hardari in Koraput district. Attack of termites was also met with in all districts. Mealy bug was severe in Koraput district only. Incidence of other pests like Pyrilla, white-fly and Lygaeid bug was negligible. A species of white grub was found damaging sugarcane roots at Raniguda farm in Rayagada area.

Madras.- Tanjore, Tiruchirappalli, Salem, South Arcot and Chingleput districts were surveyed (table 5). Heavy internode borer attack was met with in almost all the districts. In some fields in Tanjore, Tiruchirappalli and South Arcot districts the incidence was as high as 40 to 45 per cent. Top borer was serious in some localities in Tanjore and Tiruchirappalli districts. Attack of shoot borer was severe in most of the localities surveyed; in Tanjore and Tiruchirappalli districts its incidence was as high as about 30 to 36 per cent at some places. Mild attack of pink borer was met with in Tanjore

district. The scale insect, Aspidiotus glomeratus Green. was fairly serious in some areas of Tanjore and Tiruchirappalli districts. Incidence of Pyrilla, white fly and mealy bug was negligible.

The Outpost staff visited Hospet area of Mysore State also where damage to sugarcane crop by a beetle grub, Lachnosterna sp. was observed in some fields

Table 3

Survey of sugarcane pests (Madhya Pradesh)

Locality	Top borer*	Shoot borer*	Root borer*	Pink borer*	Termite*	Pyrilla**	Whitefly+	Mealybug++	Lygaeid bug++
Sehore district									
Factory farms	38.5	68.7	22.2	40.0	nil	58	nil	nil	nil
Mandsaur district									
Mandsaur Block	40.4	11.4	9.6	17.0	"	nil	"	"	"
Ratlam district									
Jaora	31.8	1.3	8.3	14.4	"	"	"	"	"
Ujjain district									
Baranagar	54.3	0.8	6.2	12.4	"	"	"	"	"
Kach Road	37.7	nil	6.2	11.1	"	"	"	"	"
Mahidpur	36.3	"	5.6	12.6	"	"	"	"	"
Indore district									
Mhow	59.2	"	3.4	7.0	"	"	"	"	"
Raind	43.0	"	1.4	7.0	"	"	"	"	"
Dewas district									
Siraulia	19.6	"	3.1	5.9	"	"	"	"	"
Shajapur district									
Kalapipal	48.0	"	5.0	nil	"	4	8	"	"
Makri	52.1	"	7.0	5.1	"	nil	nil	"	"
Bercha	21.8	7.3	6.9	13.0	"	"	"	"	"
Chilkheda	46.8	2.8	2.8	9.1	"	"	"	"	"
Gwalior district									
Dabra	30.0	30.0	14.0	nil	"	"	"	"	"
Factory farm	14.0	14.0	8.0	"	"	"	"	"	"
Bagwai	36.0	22.0	6.0	"	"	"	"	"	"
Mahrajpur	90.0	14.0	2.0	"	"	"	"	"	"
Chhimak	50.0	6.0	10.0	"	"	"	"	"	"
Shivpuri district									
Kota	60.0	20.0	nil	"	"	"	"	"	"
Guna district									
Raghavgarh	11.3	24.0	10.0	"	"	"	"	"	"
Colony	11.3	16.0	nil	"	"	"	"	"	"
Bastar district									
Moratpal	9.2	nil	"	"	"	15	7	35	"

*, **, +, ++ - Refer to foot notes under table 2

Table 4

Survey of sugarcane pests (Orissa)

Locality	Top borer*	Shoot borer*	Root borer*	Pink borer*	Termite*	Pyrilla**	Whitefly+	Mealybug++	Lygaeid bug++
Koraput district									
Jeypore	nil	10.6	1.8	nil	nil	6	5	58	nil
Hardari	"	30.3	3.4	"	2.1	nil	2	54	"
Nawrangapur	"	3.0	0.8	"	0.8	18	5	24	"
Taragam	"	12.6	2.2	"	nil	21	4	26	"
Sambalpur district									
Kandpalli	15.1	18.3	nil	"	5.6	11	16	6	"
Bolangir district									
Belaisanda	7.0	16.1	"	"	4.4	21	14	7	"
Cuttack district									
Shamsherpur	7.8	17.8	"	"	3.0	nil	2	4	"
Puri district									
Barandabanpur	22.8	16.0	"	"	5.0	"	3	2	"
Dhenkanal district									
Shankerpur	5.2	13.3	"	"	3.3	"	2	2	"
Mayurbhanj district									
Baguli	11.7	19.5	"	"	5.3	"	2	3	"
Balasore district									
Hansapur	7.5	11.6	"	"	3.1	"	1	2	"
Keonjhar district									
Fakirpur	5.6	16.7	"	"	9.1	"	4	nil	"

*, **, +, ++ - Refer to foot notes under table 2

Table 5

Survey of Sugarcane Pests (Madras)

District	Locality	Top borer*	Internode borer*	Shoot borer*	Pink borer*
Tanjor	Vadapathimangalam	12.3	36.3	13.3	0.9
	Melachetti	10.9	30.2	29.7	5.8
	Kothur	9.8	25.1	20.2	1.7
	Annakudi	20.8	10.0	5.5	0.3
	Pusangudi	7.2	39.5	11.2	0.8
	Kilyanur	8.5	27.9	22.2	0.9
Tiruchirappalli	Belur	16.6	30.9	20.7	nil
	Vangal	26.9	36.0	21.8	"
	Karur	16.1	45.6	35.2	"
	Marudur	8.3	10.0	15.8	"
	Panikkampatti	11.4	16.1	35.8	"
	Nadupatti	9.1	17.9	29.4	"
	Aryampatti	16.9	18.4	22.8	"
	Thetakuruchi	4.8	4.4	8.9	"
	Rangnampet	11.7	14.9	8.2	"
	Sonur	6.0	11.2	28.0	"
	Karpampalayam	11.7	7.0	23.6	
	Nerur	21.1	15.9	9.8	"
	Vishwanathanapuri	10.6	7.2	13.4	"
	Govindapalayam	3.1	7.7	10.4	"
Salem	Velur	18.3	28.0	17.2	"
	Kudgathur	10.2	1.5	13.2	"
South Arcot	Nalemedu	4.6	40.0	4.4	"
	Panipuram	6.9	34.0	3.0	"
	Panampet	1.8	19.0	8.0	"
Chingleput	Athur	8.3	5.3	5.0	"
	Madhuranthakam	1.4	11.0	18.8	"
	Chingleput	5.9	0.7	3.6	"

* Per cent incidence

Conclusions

The following broad conclusions can be drawn from the surveys so far carried out by the Entomological Outposts staff.

i) Top borer occurs as a serious pest in almost all the cane-growing areas of Rajasthan and Madhya Pradesh and in some parts of Madras. Its incidence is comparatively low in Orissa State.

ii) Shoot borer is serious in the early stages of the crop growth in all the four States. It causes heavy damage as cane borer also, in some parts of Rajasthan and Orissa.

iii) Root borer attack is fairly serious in Sriganganagar district of Rajasthan and Sehore district of Madhya Pradesh; it is rarely met with in Tanjore and the adjoining areas of Madras State.

iv) The pink borer occurs as a fairly serious pest in the pre-monsoon period in Sehore, Mandsaur, Ratlam and Shajapur districts of Madhya Pradesh, and in Sriganganagar and Udaipur zones of Rajasthan. In Udaipur area its activity continues till the postmonsoon period when it damages the crop as cane borer.

v) The internode borer is a serious pest in most parts of Madras State. Its sporadic attack is met with in Koraput district of Orissa also. In the Madhya Pradesh and Rajasthan its incidence has not yet been recorded.

vi) White grub damage to the sugarcane crop was recorded at Sriganganagar and Udaipur in Rajasthan, at Rayagada in Orissa and in Hospet area of Mysore State.

vii) Attack of Gurdaspur borer, B. steniellus was observed on a few shoots at the Government Agricultural Farm, Sriganganagar.

viii) Sporadic attack of Pyrilla and whitefly is met with in all cane-growing areas so far surveyed. In Sehore area of Madhya Pradesh Pyrilla usually occurs as a serious pest.

ix) Termite attack is serious in Sriganganagar and Udaipur districts of Rajasthan, Hoshangabad district of Madhya Pradesh and Rayagada area of Orissa.

x) Incidence of mealy bug is prevalent in most of the cane growing areas of Rajasthan and Orissa States. Its infestation is usually serious in Koraput district of Orissa.

xi) The scale insect, A. glomeratus occurs as a fairly serious pest in Tanjore and Tiruchirappalli districts of Madras State.

Maps showing incidence and intensity of attack of major sugarcane pests in different zones surveyed are under preparation.

4. Collection of insect fauna visiting sugarcane crop during the crop season

Sriganganagar.- A species of beetle grub damaging sugarcane roots was collected from a field at Sriganganagar in October. The adults were not met with. Another species of beetle grub was met with in a sugarcane field in Udaipur zone. Attack of Gurdaspur borer, Bissetia steniellus was observed on a few shoots at the Agri. Farm, Sriganganagar.

Sehore.- An egg mass of an unidentified species of hairy caterpillar was met with on a sugarcane leaf at the factory farm at Sehore. The mealy-bug, Icerya pilosa nardi Green and the army worm, Pseudaletia unipuncta Haw. were also collected from a sugarcane field in Gwalior region.

Rayagada.- An unidentified species of beetle, a hispa, some aphid spp. and a few other hemipterous insects were collected at Rayagada. A few caterpillars of the internode borer, P. indicus were collected at the Govt. Agri. Farm Samkhunta in Mayurbhanj district besides record of the pest at Rayagada.

Koothanallur.- Three species of leaf eating caterpillars, Gnaphalocrocis medinalis Guen., Pernara mathias F. and Pseudaletia unipuncta Haw. and two species of grass hoppers, Oxya velox F. and Cyrtacanthacris F. were collected from a sugarcane field in Tanjore district. The stink bug, Nezara viridula L. and the blister mite, Aceria sp. were collected from sugarcane leaves in a field at Koothanallur. The damage of the soil isopod, Philoscia sacchari was again recorded in some fields at the factory farm near Koothanallur. A nematode, Neotylenchus sp. was collected from the body of a top borer larva.

Observations were also recorded on the natural enemies of sugarcane pests.

Sriganganagar .- Besides the two larval parasites, Isotima javensis Row. and Vipio (Stenobracon) deesae Cam. of top borer observed earlier, the egg parasites Telenomus beneficiens Zhnt. was also recorded in some fields at Sriganganagar during 1961-62. A species of Trichogramma was observed parasitising the eggs of shoot borer, C. infuscatellus.

Sehore.- I. javensis, Elasmus zehntneri Ferr.,Rhaconotus scirpophagae Wlk. and Vipio deesae were observed parasitising top borer larvae. Parasitisation by I. javensis ranged upto 30 per cent in some fields. An egg parasite, Tetrastichus sp. was recorded on Pyrilla eggs, per cent parasitisation varying from 9 to 20.

Heavy parasitisation of Pyrilla adults and nymphs by the fungus, Metarrhizium anisopliae Metch. was observed at the factory farm from end of August to October. It resulted in almost complete mortality of the pest in the fields concerned.

Rayagada.- A dipterous parasite, Sturmiopsis inferens Tns. was recorded on the larvae of shoot borer, C. infuscatellus at Rayagada, per cent parasitisation in some fields being as high as 20. The parasite, Apanteles flavipes Cam. was also observed parasitising shoot borer caterpillars. V. deesae and I. javensis were observed parasitising top borer larvae in Angul area of Dhenkanal district. Pyrilla eggs were found parasitised by Tetrastichus pyrillae Crwf. and white fly by Azotus sp. Brumus suturalis Fabr. was observed as a predator on Pyrilla eggs and aphids in Rayagada area.

Koothanallur.- T. beneficiens and Tetrastichus sp. were recorded as egg parasites and E. zehntneri, Rhaconotus roslinensis Lal, Stenobracon nicevillei Bing., Iphiaulax fumulus Bing. and Goniozus indicus Ashm. as larval parasites of top borer. I. fumulus and G. indicus were sparingly found on shoot borer larvae also. Trichogramma evanescens minutum Riley and Tetrastichus sp. were commonly met with on the eggs of internode borer while A. flavipes and Stenobracon sp. were occasionally found parasitising the internode borer caterpillars. The fungal parasite, Aspergillus flavus Link. was also found on the internode borer larvae. Another fungal parasite, Aspergillus parasiticus Speare was recorded on the pink mealy bug, S. sacchari. Two predaceous beetles, Chilomenes sp. and Verania sp. were found destroying the puparia of white fly, A. barodensis. Two other species of beetles, Chilocorus nigritis Fabr. and Scymnus gracilis Motsch were found predating upon the scale insect, A. glomeratus.

Miscellaneous studies

Termite control experiments (Rayagada) .- (a) Two termite control experiments were carried out at the Ranigudda farm of Jeypore Sugar Co. Ltd. In the first, insecticidal dusts (table 6) and in the second

emulsions (table 7) were applied over the cane setts at planting. The attack of termites was recorded in both cases by digging out setts from 5 per cent of the total row length in two units selected at random in each plot, 12 weeks after planting.

i) Dusts .-

Table 6

Efficacy of various insecticidal dusts against termites (Rayagada)

Treatment applied at planting	Per cent germination ---- weeks after planting		Average per cent termite attack (12 weeks after planting)			
	6	8	Buds	Ends	Setts	Shoots
BHC 5 per cent dust 22.4 kg per ha	42.3	45.4	56.6	56.1	57.1	11.1
Aldrin 5 per cent dust 22.4 kg per ha	37.8	40.5	15.8	4.7	4.2	1.5
Chlordane 5 per cent dust 22.4 kg per ha	34.9	38.4	58.0	55.6	40.9	6.0
Heptachlor 6 per cent dust 18.6 kg per ha	45.0	47.9	21.7	13.9	18.3	2.5
Control	33.6	35.6	85.7	89.9	89.1	16.4

4 randomised blocks; plotwise 18 m^2; Co 419; planted 1st March 1962.

Table 7

Efficacy of various insecticidal emulsions against termites (Rayagada)

Treatment applied at planting	Per cent germination --- weeks after planting		Average per cent termite attack (12 weeks after planting)			
	6	8	Buds	Ends	Setts	Shoots
Gamma BHC 1.12 kg actual per ha	41.1	41.9	25.2	32.1	40.5	7.4
Aldrin 1.12 kg actual per ha	33.9	37.5	9.7	12.4	16.3	1.0
Dieldrin 1.12 kg actual per ha	45.9	47.5	10.2	14.7	14.7	4.3
Control (water sprayed)	29.0	30.1	76.6	71.5	67.4	13.1

4 randomised blocks; plot size 50 m^2; Co 419; planted 7th March 1962.

In the experiment with dusts, aldrin 5 per cent at 22.4 kg per hectare gave the best results followed by heptachlor 6 per cent at 18.6 kg per hectare.

ii) Emulsions .- In this the requisite insecticides were diluted with sufficient quantities of water and applied over the cane setts in furrows with a garcon can.

In this case also termite attack was least under aldrin treatment; next best results were achieved with dieldrin.

(b) In view of serious termite problem in Rayagada area, an experiment was laid out at Chekkaguda to find out if termite attack on planted material could be reduced by planting germinated setts instead of ordinary setts. This method of planting was made possible by a technique of raising a nursery under polyethylene film, developed at the Indian Institute of Sugarcane Research. Well-sprouted cane setts with growing shoots raised in a nursery duly protected with gamma BHC, were transplanted in trenches with a light irrigation. Two other treatments viz., normal planting with and without termite repellant and aretan Gammexane dip were also planted as control. Germination and termite damage were recorded 8 weeks after planting.

Table 8

Termite attack in normally planted and nursery-raised slip-setts

Treatment	Per cent germination 8 weeks after planting	Average per cent termite attack (8 weeks after planting)			
		Bunds	Ends	Setts	Shoots
rsery-raised slip-setts	64.7	20.7	57.5	45.0	6.5
rmal planting without rmite repellant	29.0	59.3	50.5	73.0	25.9
rmal planting with etan-gammexane dip	37.0	46.3	25.5	58.0	11.3

0 randomised blocks; plot size 12 m^2; Co.419; planted 11th March 1962.

Attack of termites to buds, setts and shoots was the least on nursery-raised slip-setts, but damage to cut-ends was the highest in this case apparently because the buds having already grown out as shoots, the termites diverted themselves to cut-ends although their normal preference was for buds.

Koothanallur .- Laboratory rearing of Isotima javensis Ros., a larval parasite of top borer, and Tetrastichus israeli Mani and Kurian a pupal parasite, was taken up at Koothanallur (out of the nucleus stock obtained from Pugalur) with a view to releasing the two parasites in the fields against top borer and internode borer respectively. Both the parasites bred well under laboratory conditions during the comparatively cooler months when maximum temperature ranged upto 32°C and relative humidity was above 60 per cent. But in summer months their activity declined, and rearing of T. israeli had to be discontinued. About 1600 males and females of I. javensis were released in several lots in some top borer infested fields in Tanjore district from July, 1961 to February, 1962 and the parasite was later found to have established itself in the area; the percentage parasitisation of top borer larvae ranged upto 20 in some of the release-fields. Similar releases of T. israeli which could be bred in small numbers, resulted in only stray cases of parasitisation of internode borer in some of the fields under observation.

Technical programme for 1962-63

1. Influence of individual weather conditions and general climatic conditions on the incidence and population of borers, Pyrilla and whitefly infesting sugarcane.

2. Biology of sugarcane pests.

3. Survey of cane pests.

4. Collection of insect fauna visiting sugarcane during the crop season.

Publications

David, H., Occurrence of a Neotylenchid on a Lepidopterous Larva, Curr. Sci. 31(1) : 403 (1962).

Scheme for Studies of Physical and Chemical Criteria of Gur leading to the Formulation of the Basis of Gur Grades - Indian Institute of Sugarcane Research, Lucknow.

Annual Report for 1961-62

(A.S. Sastry : Gur Chemist-in-Charge)

Objective

The objective of the Scheme is to determine the physical and chemical characteristics of gur produced in the different regions of the country so that a basis for grading gur can be formulated.

Finance and details of implementation

The Scheme was wholly financed by the Indian Central Sugarcane Committee. The financial aspects of the Scheme at the Indian Institute of Sugarcane Research, Lucknow are as follows:

Period	Grant sanctioned Rs.	Actual expenditure Rs.
Since inception	1,28,000	51,565
For the year under report	16,000	12,861

The Scheme was sanctioned by the Indian Central Sugarcane Committee in March, 1956. It was implemented at the Indian Institute of Sugarcane Research, Lucknow from 1st April, 1959 and was terminated on 28th February, 1962. This is the final year's report of the Scheme.

The work of the Scheme was to be carried out as follows. Samples of different types of gur of known characteristics were to be collected in duplicate by the State Sugarcane Research Stations at Jullundur, Shahjahanpur, Padegaon, Anakapalle, Cuddalore and Mandya. One set of samples was to be analysed at the respective State Sugarcane Research Stations, for moisture, pol, sucrose, reducing sugars, ash, insoluble impurities, pore space, etc. and the other set of samples was to be sent to the Indian Institute of Sugarcane Research, Lucknow for the determination of the influence of chemical constituents on the keeping quality, colour, texture, hardness etc. and for the evolution of standards. Bihar region was to be covered by the Sugarcane Research Station, Pusa for purposes of both the parts of the study.

Staff

The following staff were sanctioned in the scheme at the Indian Institute of Sugarcane Research.

Research Assistant (Rs.210-425)	...	...	Two
Laboratory Attendant (Rs.75-95)	...	...	One

Shri A.K. Ghosh and J.P. Bajpai continued to be Research Assistants for the whole of the year under report. The Scheme was under the technical control of the Gur Chemist of the Gur Storage Scheme.

Technical programme of work 1961-62

1. Developing analytical methods for determining various chemical constituents in gur.

2. Working out rapid methods for assessing quality, colour, texture, etc.

3. Assessing the effects of use of hydros in the manufacture of gur; on colour deterioration, and sulphur dioxide content of gur.

4. Study of variation in physical attributes and ash constituents.

5. Chemical attributes responsible for different intensities of colour, hardness and texture of gur.

6. Attributes responsible for good, medium and poor keeping quality of gur.

7. Study of keeping quality of different types of gur and their chemical composition at different times.

Non-technical summary

Analytical methods were determined for magnesium, sulphates, and sulphur dioxide. Magnesium was determined by modifying the colorimetric method of Drosdoff and Charles; sulphates by adding an excess of barium chloride and titrating with sulphuric acid using sodium rhodizonate as indicator; sulphur dioxide by the A.O.A.C. iodometric method.

A rapid method for determining the keeping quality of gur was developed. This consists of exposing three 1 cm gur cubes to 80 per cent relative humidity at 30°C for 24 hours and noting the increase in weight.

For rapid measurement of colour of gur, colour charts were prepared. Statistical examination of the data showed that the number of readings for hardness could be reduced to one reading on top surface and one on a surface exposed by cutting the block into two halves, and this on two blocks. The apparatus was also simplified and made more accurate. Texture was determined by dispersing 2 g of gur in sugar-saturated rectified spirit, centrifuging it and noting the volume of crystals.

Studies on the effects of using hydros in the manufacture of gur showed that gur prepared with hydros did not deteriorate in colour during storage more rapidly than the same gur prepared without using hydros. However, the sulphur dioxide content of gur increased with increasing doses of hydros.

Determination of physical and chemical characteristics of the samples from different States showed that the Maharashtra samples were the lightest in colour, while the U.P. ones were the darkest. Those from Madras were the hardest, the Punjab the softest. The highest crystal content was found in the samples from Andhra Pradesh and Maharashtra and the lowest in the samples of U.P. The variation in the magnesium content of samples from different States was not much. Samples from Maharashtra contained high amounts of chlorides, while U.P. samples contained the lowest amounts. U.P. samples were high in sulphates, Maharashtra samples low. The sulphur dioxide content of samples from U.P. and the Punjab was high, while samples from Maharashtra and Andhra Pradesh contained the least.

There was a moderate correlation ($r = 0.42$) between calcium content and colour. In States where lime is used as a clarificant, the correlation coefficient was higher. The correlation coefficient between texture and calcium in the samples of U.P. was -0.58. There was a slight negative correlation between hardness and moisture. In States like Andhra Pradesh and Mysore, the coefficient of correlation between hardness and moisture content was -0.84 and -0.72 respectively. In the samples of U.P. where khandsari molasses is often used in the preparation of gur, this coefficient was -0.62.

There was a moderate positive correlation between the sulphur dioxide content of gur and its bad keeping quality in the samples of U.P. The correlations between keeping quality and other physical and chemical attributes were negligible.

Detailed report

In the study for the formulation of the basis of gur grades, representative samples of gur collected during 1960-61 were received from Andhra Pradesh, Madras, Mysore, Maharashtra, Uttar Pradesh (U.P.) and the Punjab.

They were analysed for colour, hardness, texture, moisture, calcium, magnesium, chlorides, sulphates and sulphur dioxide.

1. Developing analytical methods for determining various constituents in gur

The methods followed for the determination of colour, hardness, texture, calcium and chlorides have been described in last year's annual report. The methods used/or developed for the rest of the constituents are described below.

Magnesium - The colorimetric method used by Drosdoff and Charles (Anal. Chem. 20: 673, 1948) for determining magnesium in plant tissue was modified and adapted for gur. 5 ml of 2.6 per cent gur solution was taken in a 100 ml volumetric flask and diluted with 50 ml of water. To this was added 2 ml of 5 per cent hydroxylamine hydrochloride followed by 10 ml of starch compensating solution and thoroughly mixed. 4 ml of 0.1 per cent thiazole yellow solution was then added and mixed, and the solution made alkaline with 2.5 N sodium hydroxide. It was allowed to stand for 10 minutes, made to mark and the colour read off in a Klett - Summerson photo-electric colorimeter set to zero with a blank containing all the reagents mentioned above and using a green filter. The reading for the gur solution without the reagents was subtracted from the reading for the colour developed. Magnesium in gur was determined by calibrating with standards containing known amounts of magnesium.

In the above method, magnesium was determined directly on the gur solution. In this way ashing was avoided, and rapidity of the method was increased considerably. The method was compared with gravimetric method and the results given in table 1 show that the agreement was quite close, indicating that there is no need to ash the gur (A.S. Sastry and S.S. Chatterji).

Table 1

Determination of magnesium in gur by different methods

Sample no.	Magnesium per cent gur on moisture-free basis		
	On gur as such by colorimetric method	On gur after ashing, by colorimetric method	By gravimetric method
1	0.135	0.127	0.133
2	0.225	0.228	0.232
3	0.175	0.186	0.186
4	0.133	0.139	0.133

Sulphates were determined by adding a known excess of barium chloride and titrating with standard sulphuric acid using sodium rhodizonate as indicator.

About 50 ml of half-normal gur solution were decolourised with a pinch of activated carbon and filtered 20 ml of the filtrate were taken in a glass-stoppered conical flask and treated with 1 g of ammonium chloride followed by 10 ml of 0.2 N barium chloride. The contents were titrated with 0.2 N sulphuric acid using 10 drops of freshly prepared sodium rhodizonate (15 mg in 5 ml of water) as indicator. The indicator changes from red to colourless at the end point.

Sulphur dioxide.- The iodometric titration method described in A.O.A.C. (1950 p.472) was used for the determination of free sulphur dioxide in gur.

25 g of gur were dissolved in water in a 250 ml volumetric flask, made up to volume and filtered. 100 ml of this solution were taken in a 250 ml conical flask and treated with 5 ml. dil. sulphuric

acid (1:3), 0.3 g sodium carbonate to expel air and titrated with 0.01 N iodine solution using starch as indicator. 1 ml of iodine solution is equal to 0.32 mg of sulphur dioxide.

2. Working out rapid methods for assessing quality, colour, texture etc.

Keeping quality of gur.- A rapid method for determining the keeping quality of gur has been developed. A preliminary experiment showed that the moisture content of cubes of different types of gur attains about the same level after 4 days drying over calcium chloride. Based on this finding, gur samples under comparison or test were cut into 1 cm cubes, and three such cubes for each sample were kept in desiccators at room temperature over calcium chloride for 4 days. These were then weighed and kept in desiccators at 80 per cent relative humidity at 30°C for exactly 24 hours. The percentage increase in the weight of these cubes is taken to be an inverse measure of the keeping of quality of gur.

Colour.- In order to rapidly determine the colour of gur, a colour chart was prepared. The colour of the gur samples received from the State Sugarcane Research Stations was determined by matching with colour squares in the Dictionary of Colour (Maerz, A. and Paul, M.R., 1950). The colour of a total of 322 gur samples was determined. The gur samples were found to fall into 10 colour groups as detailed in table 2.

Table 2

Classification of gur into colour groups

Colour square in Dictionary of Colour	Number of gur samples	Percentage of the total samples
10 E4	20	6.2
11 F5	31	9.6
12 F8	45	14.0
13 G8	45	14.0
14 E10	87	27.0
7 C11	9	2.8
8 H11	24	7.5
15 C10	29	9.0
16 C10	12	3.7
48 J8	20	6.2

In order to cover the colour categories of gur produced in the different regions of the country, 10 colour squares appear to be necessary. However, a survey of the important gur markets in the country showed that gur is generally graded into 4 or 5 grades. It is, therefore, suggested that the above colour squares may be grouped into five grades as shown in table 3 (A.S. Sastry, S.S. Chatterjee and M.P. Agarwal).

Table 3

Colours of proposed groups

Colour square in Dictionary of colour	Grade designation proposed	Percentage of samples in each grade
10 E4	Special	6.2
11 F5	Grade 1	9.6
12 F8, 13 G8	Grade 2	28.0
14 E10, 7 C11, 8 H11	Grade 3	37.3
15 C10, 16 C10, 48 J8	Grade 4	19.0

Hardness.- The method for the determination of hardness of gur, described in last years' report, was further perfected and is as follows:

The apparatus viz. IISR Gur Hardness Tester, consists of a wooden base with two vertical cylindrical rods. The base is fitted with a spirit level and levelling screws by adjusting which it is made horizontal. The gur block is placed on the wooden base of the instrument. A brass tube with an observation slit and graduations on the side of the slit is placed vertically over it. The vertical movement of the tube is ensured by guide bushes moving on vertical rods. A cylindrical weight with a nail attached to the centre of its bottom, just passing through the tube and weighing exactly 100 g is dropped through the brass tube from a height of 50 cm. The depth in centimetres through which the nail penetrates the gur block is measured.

In the previous method, three readings were taken on each gur block, one on either side of the block and one in the middle region after cutting the block into two, and three blocks were used for each sample. In order to see if the number of readings per sample could be reduced, the data pertaining to 36 samples from Andhra Pradesh and 45 samples from U.P. were statistically analysed. The analysis of variance is given in tables 4 and 5.

Table 4

Analysis of variance of distance in cm penetrated by the nail of the IISR-GH Tester in samples of Andhra Pradesh

Variance due to	d.f.	S.S.	M.S.	F.	Significance
Blocks	2	0.006	.003	0.10	N.S.
Surfaces	2	0.232	.116	3.87	*
Error	319	9.563	.030		
Total	323	9.801			

N.S. - Not significant; * Significant at 5 per cent level.

Summary of results

Surfaces :	Middle	Bottom	Top	SE	LSD
Mean distance in cm penetrated by the nail:	0.49	0.44	0.43	0.027	0.046

Table 5

Analysis of variance of distance in cm penetrated by the nail of the IISR-GH Tester in samples of U.P.

Variance due to	d.f.	S.S.	M.S.	F.	Significance
Blocks	2	0.004	0.002	0.04	N.S.
Surfaces	2	0.432	0.216	5.08	**
Error	400	16.987	0.043		
Total	404	17.443			

N.S. - Not significant; ** Significant at 1 per cent level

Summary of results

Surfaces:	Middle	Bottom	Top	SE	LSD
Mean distance in cm penetrated by the nail :	0.51	0.44	0.44	0.018	0.049

The above results show that the reading on the middle surface is significantly higher than that on the bottom or the top. The latter two are not significantly different from one another. It therefore appears that the surface on which hardness is determined in each gur block can be reduced to two, viz. either bottom or top, and middle.

The differences between gur blocks in the same sample were also not significant, showing thereby that the number of gur blocks on which hardness is determined can also be reduced.

From the above it appears to be sufficient to determine hardness on one gur block per sample and on its top and middle surface. However, to allow for unforeseen variations it has been decided to use two gur blocks per sample. The reciprocal of the average of the four readings is taken as hardness of the particular sample (A.S. Sastry and R.G. Menon).

Texture.- A rapid method for the determination of texture (crystal content) of gur was developed. 2 g of gur were weighed into a porcelain dish and rubbed with a small quantity of sugar-saturated rectified spirit. The contents were then transferred to a 15 ml centrifuge tube using the same spirit, and the volume made up to 15 ml. It was then centrifuged for 15 min at 2,500 rpm. The volume of the solid crystalline matter was read off, halved and multiplied by 100 to give the percentage of crystals in gur. This method was compared with the gravimetric method (table 6) and was found to give comparable results (A.S. Sastry and A.K. Ghosh).

Table 6

Crystal content of gur by the rapid method and gravimetric method

Sample no.	Crystal per cent gur	
	Rapid method	Gravimetric method
1	60	62.0
2	75	80.0
3	65	64.0
4	80	78.7
5	80	83.2
6	90	90.0

3. Assessing the effects of use of hydros in the manufacture of gur: on colour deterioration and sulphur dioxide content of gur

It is commonly believed that although hydros added to gur at the time of its manufacture improves the colour of the gur, hydros-treated gur later on darkens in colour more rapidly than untreated gur. This upsets the grading of gur as colour of gur is one of the important criteria for grading it.

In order to test this point, gur was prepared in the laboratory from the juice of B.O.17 and Co.S.510 in a specially designed pan. Just before the striking point, a removable partition was introduced into the pan to divide the contents of the pan into four portions, and different amounts of hydros were added to three of the portions, the fourth being left untreated. The gur was finished off as usual and cast into cubical moulds of 5 cm. Two such sets of cubes were prepared from each variety of cane.

The initial colour of the gur cubes was determined both by Klett-Summerson photoelectric colorimeter and with the help of the Dictionary of Colour (Maerz, A. and Paul, M.R., 1950). The cubes were then exposed to an atmosphere of 81 per cent relative humidity at room temperature (30°C) for 15 days. The final colour of the cubes was again determined by the above two methods.

Table 7

Effect of hydros on the darkening of colour of gur while in storage

Gur prepared from variety	Grams hydros added per litre of juice	Colour by photoelectric colorimeter			Colour by Dictionary Colour	
		Initial colour	Final colour after 15 days	Increase in units of colour	Initial colour	Final colour after 15 days
B.O.17 (1st set)	0.00	130	161	31	11 F 6	12 G 9
	0.25	108	134	26	11 F 6	11 G 7
	0.50	87	119	32	11 F 5	11 I 7
	0.75	77	99	22	10 F 5	11 F 6
B.O.17 (2nd set)	0.00	175	205	30	12 F 8	12 G 11
	0.25	152	203	51	11 F 6	12 G 10
	0.50	119	169	50	11 F 6	11 G 7
	0.75	122	162	40	11 H 5	11 G 7
Co.S.510 (1st set)	0.00	146	192	46	11 F 6	12 E 9
	0.25	92	128	36	10 F 4	11 F 6
	0.50	67	104	37	9 I 5	10 F 5
	0.75	68	104	36	9 H 3	10 G 6
Co.S.510 (2nd set)	0.00	157	182	25	11 H 7	12 G 10
	0.25	98	135	37	11 H 6	11 I 7
	0.50	84	115	31	11 H 5	11 I 7
	0.75	93	110	17	10 H 5	11 G 6

These results (table 7) show that hydros-treated gur does not darken in colour more rapidly than controls. The data obtained by use of photoelectric colorimeter is confirmed in visual inspection.

In order to see how hydros used in the manufacture of gur affects its sulphur dioxide content, the above gur samples were analysed.

Table 8

Effect of hydros on the sulphur dioxide content of gur

Grams hydros used per litre of juice	Sulphur dioxide ppm in gur			
	B.O.17		Co.S.510	
	1st set	2nd set	1st set	2nd set
0.00	47	52	48	67
0.25	88	119	78	75
0.50	227	225	209	188
0.75	412	295	306	256

The results (table 8) show that the sulphur dioxide content of gur increases with increasing doses of hydros. Even the smallest quantity of hydros used, viz. 0.25 g per litre increases the sulphur dioxide content of gur was as much as 75 to 119 ppm. At this level of hydros not much visual decolorisation takes place. (A.S. Sastry and J.P. Bajpai).

4. Study of variation in physical attributes and ash constituents of gur samples

Representative samples of gur received from the different State Research Stations during 1960-61 were analysed for colour, hardness, texture (crystal content), moisture, calcium, magnesium, chlorides, sulphates and sulphur dioxide. In all 281 samples have been analysed. The range of variation in these constituents is presented in table 9.

Table 9

Chemical composition of gur samples from the different States

Criterion		States, with number of samples from each					
		Punjab 58	Maha-rashtra 38	Mysore 50	Uttar Pradesh 48	Andhra Pradesh 39	Madras 48
Colour*	Mean	258	249	346	397	299	308
	S.D.±	95	71	193	185	166	187
Hardness (reciprocal of distance in cm penetrated by nail of IISR-GH Tester	Mean	1.59	2.49	2.42	2.63	2.45	4.04
	S.D.±	0.56	0.84	1.12	1.21	0.85	1.35
Crystal per cent	Mean	63.5	70.5	50.9	40.9	70.4	66.0
	S.D.±	1.6	5.3	17.1	14.4	5.0	13.3
Moisture per cent	Mean	9.31	7.03	6.85	6.58	7.48	6.37
	S.D.±	1.02	1.18	2.54	1.47	1.33	1.61
Calcium per cent	Mean	0.35	0.35	0.30	0.32	0.31	0.44
	S.D.±	0.12	0.16	0.12	0.09	0.08	0.19
Magnesium per cent	Mean	0.11	0.10	0.12	0.10	0.10	0.11
	S.D.±	0.05	0.04	0.04	0.04	0.03	0.05
Chlorides per cent	Mean	0.45	0.53	0.36	0.32	0.47	0.51
	S.D.±	0.25	0.23	0.20	0.15	0.21	0.18
Sulphates per cent	Mean	0.70	0.14	0.61	0.81	0.23	0.40
	S.D.±	0.39	0.08	0.34	0.43	0.18	0.26
Sulphur dioxide per cent	Mean	139	69	93	167	67	108
	S.D.±	63	25	56	84	31	52

* Colour was determined on a half normal solution of gur in a Klett-Summerson photoelectric colorimeter using 540 mu filter.

It is seen that Maharashtra samples were the lightest in colour while U.P. samples were the darkest. The samples from other States were intermediate in colour.

The samples from Madras were the hardest, while those from the Punjab were the softest. The samples from other States were of intermediate hardness.

Samples from Andhra Pradesh and Maharashtra had the highest crystal content, whereas those from U.P. had the lowest. Samples from the other States were intermediate in crystal content.

The moisture content of samples varied from 1.6 to 15 per cent, most of the samples having 4 to 10 per cent moisture.

Calcium content of the samples ranged from 0.11 to 1.26 per cent. Madras samples were high in calcium, while Andhra Pradesh and Mysore samples were low.

The variation in the magnesium content of the samples from different States was not much.

Chlorides in the samples varied from 0.04 to 1.6 per cent. Maharashtra samples had the highest chlorides, while U.P. samples had the lowest.

Sulphates in the samples ranged from 0.02 to 1.46 per cent. U.P. samples were high in sulphates, while Maharashtra samples were low.

Sulphur dioxide in the samples varied from 16 to 340 ppm. The highest amounts were found in U.P. and the Punjab, while the lowest were in Maharashtra and Andhra Pradesh (A.S. Sastry, S.S. Chatterjee, M.P. Agarwal).

5. Chemical attributes responsible for different intensities of colour, hardness and texture of gur

Scatter diagrams connecting physical characteristics like colour, hardness and texture with chemical constituents were prepared and examined. Where diagram suggested a fair relationship between the factors, actual correlation coefficients were worked out.

Taking gur samples from all the States into consideration, there was a moderate correlation coefficient of + 0.42 between colour and calcium. In certain States like Madras, Andhra Pradesh and Mysore, where lime is extensively used as a clarificant, it was higher and was of the order of + 0.66, + 0.63 and + 0.47 respectively. In the samples of U.P. where khandsari molasses is often used in the manufacture of gur, the correlation coefficient between colour and calcium was of the order of + 0.59. These correlation coefficients were statistically significant.

The correlation coefficient between texture (crystal content) and calcium in the samples of U.P. was negative and significant, it was of the order of - 0.58. This again appears to be due to the admixture of khandsari molasses with cane juice in the preparation of gur.

The correlation coefficient between hardness and moisture, when the samples from all the States were pooled, was of the order of - 0.33. In certain States like Andhra Pradesh and Mysore, it was as high as - 0.84 and - 0.72 respectively. In the samples of U.P. where khandsari molasses is often used in the preparation of gur, it was - 0.53. All these correlation coefficients were significant.

The correlation coefficient between hardness and calcium in U.P. samples was significant and negative (- 0.62). This again points to the use of khandsari molasses in the preparation of gur in this State.

The correlations between physical characteristics and other chemical constituents appeared to be negligible and were not calculated (A.S. Sastry).

6. Attributes responsible for good, medium and poor keeping quality of gur

The keeping quality of gur samples from the different States was determined by the method described in the preceding pages. Scatter diagrams connecting the keeping quality with physical and chemical attributes of gur were prepared and examined. Where a fair correlation was indicated, actual correlation coefficients were calculated.

There was a moderate but significant negative correlation of - 0.45 between the sulphur dioxide content of gur and its keeping quality in the sample of U.P. This appears to be due to use of khandsari molasses in the preparation of gur in this State.

Correlations between keeping quality and other physical and chemical attributes appeared to be low and were not calculated (A.S.Sastry

7. Keeping quality of different types of gur and their chemical composition at different times

Periodic analyses of gur samples at different times through monsoon were carried out by the collaborating State Sugarcane Research Stations and these data are being obtained and examined to find out the premonsoon, monsoon and postmonsoon composition of gur.

Scheme for Studies in Storage of Gur

Indian Institute of Sugarcane Research, Lucknow.

Annual Report for 1961-62

(A.S. Sastry : Gur Chemist-in-Charge)

Objective

The objective of the Scheme is to elucidate by systematic studies, the effect of various environmental and other factors on the keeping quality of gur with the ultimate objective of evolving suitable methods of storage.

Finance and details of implementation

The Scheme was wholly financed by the Indian Central Sugarcane Committee. The financial aspects of the Scheme are as follows:

Period	Grant sanctioned Rs.	Actual expenditure Rs.
Since inception	1,75,000	50,450
For the year under report	25,000	26,545

The Scheme was sanctioned by the Indian Central Sugarcane Committee in April, 1958. It was implemented from May, 1959. This is the third annual report of the Scheme.

Staff

The following staff was sanctioned in the Scheme during tha year under report.

Gur Chemist (Rs.700-1250)	...	...	One
Research Assistants (Rs.210-425)	...	...	Two
Laboratory Attendant (Rs.75-95)	...	...	One

Shri A.S. Sastry continued as Gur Chemist and Shri M.P. Agarwal and Shri S.S. Chatterji as Research Assistants till 28th February, and 20th January, 1962 respectively. Shri A.K. Ghosh and Shri J.P. Bajpai were transferred from the Gur Grading to the Gur Storage Scheme from 1st March, 1962.

Technical programme of work 1961-62

1. Elucidation of the exact physical conditions causing deterioration of gur while in storage.

   i) Effect of temperature and humidity on the keeping quality of gur.

   ii) Comparative tests on storage of gur, and the assessment of conditions in trade godowns.

   iii) Effect of cold storage on the keeping quality of gur.

   iv) Effect of pressure on the keeping quality of gur.

2. The relationship between the chemical constituents of gur and spoilage in stored gur.

   i) Effect of maturity in the different varieties on the keeping quality of gur.

   ii) Influence of clarificants on the keeping quality of gur.

iii) Influence of chemical constituents on the keeping quality of gur: a) ash constituents, b) sugar constituents, c) hydros, d) nitrogenous substances.

3. Designing and testing of a suitable godown,

i) for storage of gur for trade purposes.

ii) for storage in villages and small growers' co-operatives.

Non-technical summary

A large number of gur samples kept for 7 months at room temperature and 58 per cent relative humidity underwent a loss of only about 1 per cent in weight, showing thereby that at 58 per cent RH the samples were very nearly at their equilibrium humidity. Changes in sucrose and reducing sugars of most of the samples were negligible. In those samples whose initial moisture content exceeded 8 per cent, inversion losses occurred. The losses in weight, inversion losses and darkening in colour were much more in the first 3 months than in the subsequent 4 months, probably because of the higher temperatures which prevailed during the first 3 months.

Comparative tests on the storage of gur in trade godowns at Rajahmundry, Kolhapur, Dankaur and Muzaffarnagar showed that temperatures inside the godown at Muzaffarnagar were about 33°C throughout the period of storage (May to September 1961); at Rajahmundry and Dankaur, they were high till the end of June (36°C), and then decreased by about 8°C. At Kolhapur, they were about 30°C in June and fell by about 3°C thereafter. Humidities were the lowest (48 to 75 per cent) at Muzaffarnagar. Dankaur humidities were comparable with those of Muzaffarnagar except in August when they were about 85 per cent. The humidities at Rajahmundry were high from the beginning, while at Kolhapur they were somewhat low in June and increased considerably during the later period.

Studies at Rajahmundry showed that the first 2-3 smoke treatments with paddy husk given in the godown after the commencement of the monsoon had no effect either in increasing the temperature or reducing the humidity, probably due to release of moisture from the floor and walls of the godown. Only after the 4th smoking was there a rise in temperature of about 3°C and a decrease in humidity to about 65 per cent.

Chemical analyses of gur during the storage period showed that under Rajahmundry conditions where the humidities were high, gur absorbed considerable amounts of moisture even by the end of June, and started running out. Due to the bedding of cane trash given to these samples, there was an initial increase in weight in some samples. As long as smoking lasted there was not much inversion loss. At Kolhapur also, gur absorbed considerable amounts of moisture, and weight losses occurred in all the samples except one which was the best type of gur. Inversion losses occurred in all the samples by the end of July. At Dankaur and Muzaffarnagar where high temperatures and low humidities prevailed during June, most of the gur samples lost weight due to dryage. Later on the moisture content of gur increased and losses in weight occurred due to draining of molassine portions. The losses in weight were more at Dankaur than at Muzaffarnagar in most of the samples. Inversion losses occurred in all the samples towards the end of the storage period. On the whole Muzaffarnagar conditions appeared to be the best.

The quality of gur appeared to govern the changes brought about in its composition during storage. Where high humidities prevailed from the very beginning, as at Rajahmundry and Kolhapur, there was an initial decrease in reducing sugars due to draining of molassine portions in the case of bad gur; this change was not observed in good gur. The rate of absorption of moisture was more or less similar in good and bad gur. But good gur could hold more moisture without liquefaction and thus the losses of weight in it were less.

Under commercial cold storage conditions, where humidities as high as 80 to 85 per cent prevailed, gur absorbed moisture and increased in weight. However, there were no inversion losses.

At 72.5 per cent atmospheric humidity, gur could stand a pressure of only 35 g per cm^2, while at 58 per cent relative humidity, it could stand thrice this pressure.

Gur of Co.997 contained more sucrose and less reducing sugars than that of Co.951; it had a better keeping quality at all stages of maturity of cane.

Magnesium sulphate and glucose adversely affected the keeping quality of gur, while sucrose was favourable.

Godowns for storage of gur under village conditions and for trade purposes have been designed by the Agricultural Engineer.

Detailed report

1. Elucidation of the exact physical conditions causing deterioration of gur while in storage

i) Effect of temperature and humidity on the keeping quality of gur

In the studies reported last year, it was found that the optimum relative humidity (RH) for preservation of gur lay between 51 and 58 per cent. In order to see whether this is true of gur in general, a large number of gur samples (from different States), whose initial moisture content ranged from 5.6 to 10.0 per cent were cut into cubes of 3.8 cm size and kept in desiccators at 58 per cent RH at room temperature for 7 months. As at 51 per cent r h the chemical changes in gur might be negligible, the higher humidity of 58 per cent was chosen.

The samples were analysed initially and at the end of 3 months and 7 months of storage for possible changes in weight, moisture, sucrose, reducing sugars and colour. The temperature of the room during the experiment was continuously recorded by a thermo-hygrograph. The average room temperature was 27.4°C in the first 3 months, 17.2°C in the subsequent 4 months, and for the entire period 21.9°C.

The results (table 1) show that all the gur samples decreased in weight by about 1 per cent in 7 months. This shows that they were very nearly at their equilibrium humidity (RH). The reduction in weight of these samples was not related to the initial moisture content of the samples. There was also a decrease in the moisture content of all the samples.

Changes in sucrose and reducing sugars of most of the samples were not beyond experimental error. In most cases where the initial moisture of the samples exceeded 8 per cent, losses in sucrose and increases in reducing sugars were witnessed.

The colour of all the samples increased. The losses in weight, losses due to inversion, and darkening in colour were much more in the first 3 months than in the subsequent 4 months, presumably due to the higher temperatures.

The results show that even at RH , losses due to inversion of sucrose occur if the initial moisture of the gur samples exceeds 8 per cent. Hence for the preservation of gur even at RH , the moisture content should be low preferably below 5 per cent (A.S. Sastry and J.P. Bajpai).

Table 1

Physical and chemical changes in gur kept at 58 per cent relative humidity at room temperature

Particulars of sample	Time of analysis	Change in weight per cent	Moisture per cent	Sucrose per cent	Reducing sugars per cent	Colour*
Kopergaon grade 1	Initial	0.0	7.71	86.56	9.73	130
	After 3 months	-1.7	4.59	86.39	9.54	169
	After 7 months	-2.1	5.08	86.11	10.01	184
Kopergaon grade 1	Initial	0.0	7.65	80.13	15.40	188
	After 3 months	-0.9	6.31	78.81	16.42	200
	After 7 months	-0.9	7.06	78.92	15.77	275
Kopergaon grade 3	Initial	0.0	8.17	78.57	17.21	348
	After 3 months	-0.5	8.53	76.53	19.23	454
	After 7 months	-1.1	7.20	75.36	17.65	495
Kopergaon grade 3	Initial	0.0	9.71	80.25	14.62	332
	After 3 months	-0.6	8.09	76.78	16.80	413
	After 7 months	-0.9	8.40	76.00	17.96	495
Kolhapur grade 1	Initial	0.0	7.73	86.25	11.22	143
	After 3 months	-1.5	4.66	85.50	11.01	183
	After 7 months	-1.6	5.32	85.02	11.53	218
Kolhapur grade 1	Initial	0.0	7.49	79.67	15.52	257
	After 3 months	-0.7	6.52	80.24	16.77	310
	After 7 months	-0.6	7.14	79.31	16.17	366
Kolhapur grade 3	Initial	0.0	8.03	82.82	14.52	242
	After 3 months	-0.8	6.83	81.30	15.35	284
	After 7 months	-1.1	5.78	81.05	15.05	310
Sangamner grade 1	Initial	0.0	8.85	79.49	16.94	384
	After 3 months	-1.3	6.64	78.55	15.96	621
	After 7 months	-1.5	7.00	78.54	15.99	680
Sangamner grade 3	Initial	0.0	10.02	83.27	16.47	296
	After 3 months	-1.0	8.05	78.11	17.81	413
	After 7 months	-1.0	8.35	75.62	18.18	365
Sangamner grade 3	Initial	0.0	6.17	81.35	11.08	286
	After 3 months	-1.0	5.67	81.69	11.70	355
	After 7 months	-1.5	6.11	81.11	11.98	385
Aurangabad grade 3	Initial	0.0	8.73	79.73	12.59	318
	After 3 months	-1.2	5.32	81.09	12.71	350
	After 7 months	-0.7	5.56	79.64	11.77	395
Uttar Pradesh	Initial	0.0	9.55	69.84	20.44	641
	After 3 months	-0.5	8.79	68.11	20.86	700
	After 7 months	-0.3	8.88	67.54	19.88	889
Uttar Pradesh	Initial	0.0	5.60	83.97	10.40	625
	After 3 months	-0.7	3.65	83.33	10.42	670
	After 7 months	-0.8	4.56	82.38	10.85	796

* Colour was determined on a half-normal solution of gur using Klett-Summerson photoelectric colorimeter and 540 mu filter.

ii) Comparative tests on storage of gur and assessment of conditions in trade godowns

In order to make a comparative study of storage conditions in different trade godowns and the effects of these on stored gur, special arrangements were made with commercial godown-owners in the principal gur markets of India for carrying out the experiments and for collection of data. Gur of different qualities was prepared for this purpose, divided into lots and stored under trade conditions in godowns at Rajahmundry, Kolhapur*, Dankaur and Muzaffarnagar. Thermo-hygrographs were installed for recording temperature and humidity inside the godowns. The stored gur was weighed monthly and samples were drawn from it and analysed for moisture, sucrose, reducing sugars, colour and pH.

The experiment was started at Muzaffarnagar on 26th April, at Rajahmundry on 15th May, at Kolhapur on 19th May and at Dankaur on 28th May, 1961. Smoke-treatment as per local practice was started in the Rajahmundry godown on 20th June and continued at approximately 10-day intervals, till 22nd July. The trader's gur was withdrawn from the godown on 4th August and no smoking was given after 22nd July. At Dankaur the trader vacated the godown on 25th August. At Kolhapur and Muzaffarnagar, the tests continued for the entire monsoon period.

Methods of storage in the different godowns.- At Rajahmundry gur was packed in palmyrah leaf baskets having a bedding of cane trash or leaves. The godowns were smoke-treated once in 10 days by incinerating paddy husk in a 10 cm layer. At Kolhapur the gur was wrapped in hessian and stored in cotton seed. At Dankaur, naked bhelies were stored in a room on the first floor, made of earth. They were piled to a height of about 120 cm. At Muzaffarnagar, gur was stitched in gunnies and stored in an ordinary room.

Quality of gur samples.- The chemical composition of the gur samples which were subdivided and stored in the different godowns is given in table 2.

Table 2

I

Initial chemical composition of gur samples stored in different trade godowns

Particulars	Sample A	Sample B	Sample C	Sample D
Moisture per cent	7.75	6.51	6.67	6.09
Sucrose per cent	78.98	82.60	86.45	83.96
Reducing sugars per cent	11.66	7.70	9.87	9.22
Glucose/Sucrose x 100	14.77	9.32	11.48	10.97
Colour of gur solution*	460	593	479	496
pH	5.59	5.65	5.73	5.55
Calcium per cent	0.33	0.37	0.39	0.28
Magnesium per cent	0.11	0.06	0.08	0.06
Chlorides per cent	0.29	0.36	0.34	0.29
Sulphates per cent	0.71	0.61	0.50	0.80

* Colour was determined as indicated under table 1.

Sample A was of the poorest quality, being the lowest in sucrose and highest in reducing sugars. It also had the highest magnesium content. Sample B was intermediate in sucrose and lowest in reducing sugars. Samples C and D were high in sucrose and fairly high in reducing sugars. Sample C was more or less the best in quality.

* Our thanks are due to the warehouse man of the Central Warehousing Corporation, Kolhapur for his help and co-operation in the conduct of the experiment.

Temperature and humidity in different godowns.- The temperature and humidity data during storage period in the different godowns are presented in table 3 and 4.

Table 3

Temperature °C during the periods between samplings

Period	Rajahmundry	Kolhapur	Muzaffarnagar	Dankaur
Initial to 1st sampling (end of June)	35.7 ± 1.4	30.1 ± 1.0	33.5 ± 0.7	35.6 ± 0.7
1st to 2nd sampling (end of July)	27.2 ± 1.3	26.7 ± 0.8	33.2 ± 0.4	28.2 ± 0.2
2nd to 3rd sampling (end of August)	28.3 ± 1.3	27.2 ± 1.5	31.3 ± 0.9	25.7 ± 0.4
3rd to 4th sampling (end of September)	27.1 ± 1.3	26.7 ± 2.0	31.5 ± 0.3	28.4 ± 0.9

Table 4

Relative humidity per cent during the periods between samplings

Period	Rajahmundry	Kolhapur	Muzaffarnagar	Dankaur
Initial to 1st sampling (end of June)	71.04 ± 7.56	67.49 ± 7.30	48.05 ± 3.5	49.01 ± 2.90
1st to 2nd sampling (end of July)	86.81 ± 4.25	87.33 ± 3.30	68.30 ± 1.12	70.87 ± 1.90
2nd to 3rd sampling (end of August)	73.80 ± 4.93	83.22 ± 7.89	75.50 ± 1.32	83.59 ± 1.44
3rd to 4th sampling (end of September)	78.51 ± 4.24	87.57 ± 6.38	71.75 ± 2.43	73.29 ± 1.88

Temperatures inside the godown at Muzaffarnagar were high throughout (about 33°C), while at Rajahmundry and Dankaur they were high till the end of June (36°C), and then decreased by about 8°C. At Kolhapur, they were about 30°C in June and then decreased by about 3°C.

The humidities in Muzaffarnagar were the lowest throughout (48 to 75 per cent). Dankaur humidities were comparable with those in Muzaffarnagar except in August when they were quite high (about 85 per cent). Rajahmundry humidities were high from the beginning, while at Kolhapur they were somewhat low in June and increased considerably during the later period.

Effect of smoke treatment on temperature and humidity within the godown.- At Rajahmundry smoke treatment was started late i.e. on 20th June, 1961 and was continued at approximately ten day intervals. In order to assess the effect of this treatment, the atmospheric conditions inside the godown were compared with those outside[1], before and after the smoke treatment.

Table 5

Effect of smoke treatment on temperature and humidity inside Rajahmundry godown

Date	Inside godown		Outside godown	
	Average temperature	Average relative humidity	Average temperature	Average relative humidity
19.6.61	27.00 ± 0.00	95.0 ± 2.00	26.60 ± 1.00	85.0 ± 6.0
20.6.61*	27.00 ± 1.00	95.5 ± 0.5	27.70 ± 2.70	91.0 ± 0.0
21.6.61*	27.00 ± 1.00	96.0 ± 1.0	26.45 ± 2.05	96.5 ± 1.5
22.6.61*	27.00 ± 1.00	97.0 ± 1.0	26.65 ± 2.55	81.5 ± 9.5
23.6.61	27.00 ± 1.00	93.0 ± 5.0	29.05 ± 2.95	70.0 ± 23.0
29.6.61	29.25 ± 0.75	92.5 ± 4.5	28.80 ± 4.20	75.5 ± 15.5
30.6.61*	28.75 ± 1.25	90.0 ± 5.0	29.1 ± 4.10	74.0 ± 15.0
1.7.61*	29.50 ± 0.50	90.5 ± 1.5	29.0 ± 4.00	87.0 ± 8.0
2.7.61*	28.50 ± 0.50	93.5 ± 1.5	27.1 ± 2.40	73.0 ± 22.0
3.7.61	25.00 ± 1.00	96.0 ± 1.0	27.2 ± 1.60	73.0 ± 7.0
12.7.61	26.50 ± 0.50	**	26.40 ± 2.60	85.0 ± 10.0
13.7.61*	28.00 ± 2.00	**	26.25 ± 2.75	83.0 ± 10.0
14.7.61*	31.50 ± 1.50	**	26.10 ± 2.10	78.5 ± 14.5
15.7.61*	29.00 ± 1.00	**	28.20 ± 4.30	78.5 ± 12.5
16.7.61	28.50 ± 0.50	**	29.25 ± 2.55	83.5 ± 2.5
21.7.61	23.50 ± 1.50	**	27.35 ± 2.65	90.0 ± 3.0
22.7.61*	22.75 ± 2.25	**	26.15 ± 3.05	96.5 ± 1.5
23.7.61*	27.50 ± 1.50	**	25.15 ± 2.25	82.5 ± 10.5
24.7.61*	28.00 ± 1.00	64.5 ± 2.5	27.40 ± 3.20	86.0 ± 9.0
25.7.61	28.50 ± 1.50	65.0 ± 3.0	27.40 ± 3.00	84.5 ± 8.5

* Smoke treatment was given on these dates.
** Thermo-hygrograph went out of order in this period.

The first two smoke treatments given on 20th and 30th June each time lasting 3 days did not seem to have any effect on the temperature and humidity inside the godown, probably because of the release of moisture from the floor and walls of the godown. The thermo-hygrograph went out of order from 11th to 23rd July and the effect of smoking given on 13th July could not therefore be assessed. After the 4th smoke treatment given on 22nd July, the temperature inside the godown rose by about 3°C and the humidity decreased from 85 to about 65 per cent.

Effect of temperature and humidity inside the godowns on the chemical composition of gur.- The chemical changes in gur samples during storage in the different godowns are shown in tables 6, 7, 8 and 9. All the constituents are expressed on moisture-free basis, except pH, moisture and weight of gur which are on original gur basis.

1. The meteorological data which nearly represents conditions outside the godown were kindly supplied by the Director, Central Tobacco Research Institute, Rajahmundry.

Under Rajahmundry conditions where the humidities were high throughout the storage period, gur absorbed considerable amounts of moisture even by the end of June and started running out as may be seen by the decrease in colour of all the samples. Due to the bedding of cane trash given to these samples, there was an initial increase in weight of some samples. As long as smoke treatment lasted (till the end of July), there were no inversion losses. Afterwards, losses of sucrose and increase in reducing sugars occurred in all the samples except A which was a poor sample, and in which sucrose actually increased and reducing sugars decreased, presumably due to draining of molassine portions

Table 6

Chemical changes during storage of gur sample A

Location of godown	Particulars	Initial	Sample taken on: Last week of June '61	Last week of July '61	Last week of Aug. '61	1st week of Oct. '61
Rajahmundry	Weight per cent initial weight	100.0	103.7	94.0	93.2	100.6
	Moisture per cent	7.92	9.12	10.81	11.01	10.62
	Sucrose per cent	78.61	78.60	83.01	84.18	83.55
	Reducing sugars per cent	11.77	10.02	10.95	10.45	8.84
	Colour of gur solution**	434	209	533	416	543
	pH	5.65	5.65	5.75	5.70	5.70
Kolhapur	Weight per cent initial weight	100.0	100.0	100.4	97.9	87.5
	Moisture per cent	7.65	6.96	10.07	11.05	11.83
	Sucrose per cent	79.37	79.62	79.80	79.03	81.23
	Reducing sugars per cent	11.64	10.32	13.69	13.69	11.68
	Colour of gur solution**	536	381	506	433	550
	pH	5.70	5.70	5.70	5.60	5.65
Dankaur	Weight per cent initial weight	100.0	92.5	90.1	82.3	79.8
	Moisture per cent	7.92	4.49	7.09	8.38	10.03
	Sucrose per cent	78.27	76.96	81.98	81.93	81.27
	Reducing sugars per cent	11.54	10.91	11.88	11.79	12.72
	Colour of gur solution**	434	544	538	475	511
	pH	5.50	5.75	5.70	5.70	5.65
Muzaffarnagar	Weight per cent initial weight	100.0	98.4	99.2	102.6	102.6
	Moisture per cent	7.51	5.03	5.05	8.27	8.77
	Sucrose per cent	79.68	82.92	77.65	80.68	82.14
	Reducing sugars per cent	11.69	10.81	12.14	11.71	11.07
	Colour of gur solution**	434	400	548	480	592
	pH	5.50	5.75	5.70	5.70	5.60

* Colour was determined as indicated under table 1.

At Kolhapur, humidities and temperatures were lower than at Rajahmundry during June. From July onwards, they were about the same at both the places. Due to this reason, the absorption of moisture by gur samples was less at Kolhapur than at Rajahmundry during June, but during the later months all the gur samples absorbed considerable amounts of moisture. Weight changes were small upto the end of July in all the samples. Afterwards, weight losses occurred in all except sample C, which was the best sample. Inversion losses occurred in all the samples by the end of July. Colour decreased initially followed by increases.

Table 7

Chemical changes during storage of gur sample B

Location of godown	Particulars	Initial	Sample taken: Last week of June '61	Last week of July '61	Last week of Aug. '61	1st week of Oct. '61
Rajahmundry	Weight per cent initial weight	100.0	103.8	97.3	99.9	108.8
	Moisture per cent	6.45	8.90	10.90	11.42	11.10
	Sucrose per cent	82.62	82.20	88.33	81.09	83.67
	Reducing sugars per cent	8.02	8.63	6.22	12.69	8.79
	Colour of gur solution**	593	351	629	559	652
	pH	5.70	5.80	5.80	5.65	5.70
Kolhapur	Weight per cent initial weight	100.0	100.0	100.3	99.8	93.0
	Moisture per cent	6.75	7.43	10.87	11.30	9.57
	Sucrose per cent	82.14	83.60	83.67	83.41	83.87
	Reducing sugars per cent	7.57	7.58	8.92	10.73	5.71
	Colour of gur solution**	584	438	500	631	476
	pH	5.80	5.70	5.70	5.70	5.70
Dankaur	Weight per cent initial weight	100.0	95.2	96.8	94.8	93.2
	Moisture per cent	7.00	5.00	6.86	8.95	9.05
	Sucrose per cent	83.68	83.30	81.98	85.18	84.41
	Reducing sugars per cent	7.62	7.68	8.58	7.95	9.32
	Colour of gur solution**	559	558	601	615	627
	pH	5.50	5.80	5.80	5.75	5.50
Muzaffarnagar	Weight per cent initial weight	100.0	97.3	99.4	100.1	100.1
	Moisture per cent	5.85	5.60	6.14	8.36	7.96
	Sucrose per cent	83.95	84.72	86.16	82.11	83.74
	Reducing sugars per cent	7.59	7.75	8.36	8.78	7.41
	Colour of gur solution**	637	577	587	786	826
	pH	5.60	5.85	5.70	5.70	5.70

** Colour was determined as indicated under table 1.

At Dankaur and Muzaffarnagar, where high temperatures and low humidities prevailed during June, most of the gur samples lost moisture and weight due to dryage. Later on the moisture content of gur increased resulting in draining of malassine portions and consequent losses in weight. The losses in weight were more at Dankaur than at Muzaffarnagar in most of the samples, probably because of higher humidities which prevailed at Dankaur during August. Inversion losses occurred in all the samples towards the end of the storage period. Colour of most of the gur samples increased during storage.

On the whole gur preserved best under Muzaffarnagar conditions.

Table 8

Chemical changes during storage of gur sample C

Location of godown	Particulars	Initial	Sample taken during			
			Last week of June '61	Last week of July '61	Last week of Aug. '61	1st week of Oct. '61
Rajahmundry	Weight per cent initial weight	100.0	100.0	97.3	96.3	97.7
	Moisture per cent	7.31	10.14	10.41	11.94	12.73
	Sucrose per cent	86.09	86.04	85.78	82.28	80.03
	Reducing sugars per cent	10.88	11.28	8.66	12.84	12.51
	Colour of gur solution**	479	428	486	437	516
	pH	5.75	5.75	5.85	5.65	5.65
Kolhapur	Weight per cent initial weight	100.0	100.0	100.6	101.5	100.7
	Moisture per cent	6.34	8.47	9.62	11.56	11.17
	Sucrose per cent	85.89	84.31	82.60	79.12	77.95
	Reducing sugars per cent	9.84	9.50	9.41	16.71	16.63
	Colour of gur solution**	474	421	525	611	456
	pH	5.70	5.70	5.70	5.70	5.70
Dankaur	Weight per cent initial weight	100.0	101.8	102.5	102.5	99.0
	Moisture per cent	6.12	5.73	7.13	9.35	9.04
	Sucrose per cent	86.17	83.87	85.17	83.51	80.39
	Reducing sugars per cent	8.91	10.66	10.71	12.18	11.87
	Colour of gur solution**	484	517	431	483	462
	pH	5.80	5.85	5.80	5.80	5.70
Muzaffarnagar	Weight per cent initial weight	100.0	98.0	98.6	98.0	98.0
	Moisture per cent	7.02	5.06	7.97	8.62	8.39
	Sucrose per cent	87.65	81.85	84.76	83.01	84.13
	Reducing sugars per cent	9.85	10.85	12.32	12.01	9.82
	Colour of gur solution**	479	458	494	591	579
	pH	5.75	5.85	5.80	5.80	5.70

** Colour was determined as indicated under table 1.

Effect of quality of gur on its preservation.- From the quality point of view, gur sample A was the poorest, while C might be considered to be the best. Initial quality appears to govern to some extent the changes brought about in the composition of the gur during storage. For instance, under Rajahmundry and Kolhapur conditions where humidities were very high from the beginning, there was an initial decrease in reducing sugars due to deliquescence and draining of molassine portions in sample A. Such a change was not observed in sample C. Under the drier conditions of Dankaur and Muzaffarnagar this change was not observed.

Table 9

Chemical changes during storage of gur sample D

Location of godown	Particulars	Initial	Sample taken during: Last week of June '61	Last week of July '61	Last week of Aug. '61	1st week of Oct. '61
Rajahmundry	Weight per cent initial weight	100.0	98.5	90.4	95.8	99.7
	Moisture per cent	6.64	9.71	10.02	11.88	12.12
	Sucrose per cent	84.40	85.98	82.00	79.07	82.23
	Reducing sugars per cent	9.10	10.13	9.31	13.84	10.81
	Colour of gur solution**	482	410	409	420	518
	pH	5.60	5.65	5.65	5.50	5.55
Kolhapur	Weight per cent initial weight	100.0	100.0	100.6	101.2	99.3
	Moisture per cent	5.65	8.65	9.52	9.97	11.35
	Sucrose per cent	83.20	81.62	82.79	80.12	79.12
	Reducing sugars per cent	8.80	9.32	10.55	15.84	14.50
	Colour of gur solution**	498	438	547	433	620
	pH	5.50	5.70	5.60	5.55	5.60
Dankaur	Weight per cent initial weight	100.0	92.2	90.6	96.3	94.5
	Moisture per cent	5.44	4.67	7.81	10.19	9.05
	Sucrose per cent	84.07	83.62	84.65	80.32	82.77
	Reducing sugars per cent	9.62	8.78	10.67	12.22	9.64
	Colour of gur solution**	507	582	452	370	660
	pH	5.60	5.75	5.70	5.60	5.40
Muzaffarnagar	Weight per cent initial weight	100.0	99.7	100.4	100.4	100.4
	Moisture per cent	6.62	5.40	7.90	7.88	8.43
	Sucrose per cent	84.17	84.29	84.68	83.85	85.50
	Reducing sugars per cent	9.36	8.26	10.77	10.90	7.84
	Colour of gur solution**	496	386	478	543	601
	pH	5.60	5.70	5.60	5.60	5.50

** Colour was determined as indicated under table 1.

The effect of quality of gur is also seen in the weight losses suffered by the gur in storage. Under Dankaur conditions where naked lumps were stored, and other extraneous conditions like bedding of cane trash and leaves (as in Rajahmundry) did not interfere, weight losses were maximum in sample A this being of the poorest quality, while they were minimum in the case of sample C which was the best.

Good gur does not appear to differ much from poor gur insofar as rate of absorption of moisture is concerned. The only difference is that it can hold more moisture without liquefaction, and this minimises losses in weight during storage (A.S. Sastry and A.K. Ghosh).

iii) Effect of cold storage on the keeping quality of gur

In order to study the effect of low temperature on the keeping quality of gur, gur of different qualities was placed in polyethylene-lined gunnies and stored in a commercial cold-storage godown. The temperature and humidity in cold storage were recorded by a thermo-hygrograph and were found to be 1.05°C ± 0.5°C and 83.43 ± 2.4 per cent respectively. Samples were drawn at intervals and analysed for change in weight, moisture, sucrose, reducing sugars, colour and pH. The results are shown in table 10.

The humidity inside the cold storage godown was very high, being between 80 and 85 per cent. Under these conditions, gur absorbed moisture and increased in weight probably due to absorption of moisture through the seams of the bags. Sometimes molassine portions oozed out and settled at the bottom of the polyethylene-lined gunnies leading to improvement in colour as in the case of samples 1, 3, 4 and 6. In samples 2 and 5 the increase in weight was the least and probably there was no draining of molasses till the end. Under these conditions, there were indications of an initial darkening of colour followed by improvement at the end.

Changes in sucrose and reducing sugars were negligible in the samples, indicating that there were no inversion losses. pH changes (not shown in the table) were also negligible (A.S. Sastry and A.K. Ghosh).

iv) Effect of pressure on the keeping quality of gur

It is common experience that when gur bags or lumps are stacked one over the other in tiers, gur in the lower tiers deteriorates more rapidly than that in the upper ones. This is due to the pressure exerted by the upper bags. In order to determine the pressure which gur can stand during storage, a preliminary laboratory experiment was conducted.

Gur cubes of 3.8 cm size were subjected to 0, 35 g, 70 g and 105 g per cm^2 pressure, at room humidity (mean 72.5 per cent) and 58 per cent relative humidity, all 8 treatments being at room temperature (mean 31°C). 58 per cent relative humidity was obtained by keeping a saturated solution of sodium bromide under a bell jar and sealing the bell jar to the base plate. The gur cubes were placed in petri dishes and pressures were applied by placing trays, with the required quantity of sand, over the cubes. Over gur cubes used as controls no trays were placed. The experiment was run for 30 days. Due to paucity of staff only one cube was used in each treatment.

It was observed that under room humidity, the gur cube subjected to 105 g per cm^2 pressure collapsed after 92 hours, while that under 70 g per cm^2 pressure collapsed after 30 days. The one under 35 g per cm^2 pressure had not collapsed when the experiment was terminated. The cube at 58 per cent relative humidity did not collapse in 30 days even under as high a pressure as 105 g per cm^2. This shows that the pressure which gur could stand during storage depends on the relative humidity of the atmosphere.

Table 10

Effect of cold storage on the chemical composition of gur (all results except moisture expressed on moisture-free basis)

Particulars of gur sample	Constituents analysed	Initial	Analysed in the Middle of July 1961	Middle of August 1961	Middle of October 1961
Sample no.1	Weight per cent initial weight	100.0	102.0	103.0	106.2
	Moisture per cent	6.67	9.31	9.49	10.70
	Sucrose per cent	80.62	82.85	80.89	81.25
	Reducing sugars per cent	12.15	12.40	13.69	12.36
	Colour of N/2 gur solution**	508	425	454	454
Sample no.2	Weight per cent initial weight	100.0	101.8	102.7	102.7
	Moisture per cent	6.31	7.79	8.70	8.79
	Sucrose per cent	83.89	84.62	83.18	86.13
	Reducing sugars per cent	10.83	9.13	9.08	8.00
	Colour of N/2 gur solution**	352	515	597	493
Sample no.3	Weight per cent initial weight	100.0	105.5	108.3	108.3
	Moisture per cent	3.19	4.56	6.74	8.65
	Sucrose per cent	82.87	84.69	84.83	84.51
	Reducing sugars per cent	9.80	9.23	10.04	9.51
	Colour of N/2 gur solution**	389	388	293	343
Sample no.4	Weight per cent initial weight	100.0	103.4	103.4	105.8
	Moisture per cent	3.79	4.65	5.99	8.25
	Sucrose per cent	83.37	82.18	84.55	83.05
	Reducing sugars per cent	9.91	9.25	8.65	8.52
	Colour of N/2 gur solution**	499	489	303	264
Sample no.5	Weight per cent initial weight	100.0	102.6	103.6	104.6
	Moisture per cent	4.69	7.97	8.90	9.25
	Sucrose per cent	83.86	83.61	81.59	82.93
	Reducing sugars per cent	10.17	11.51	11.35	10.63
	Colour of N/2 gur solution**	487	489	582	441
Sample no.6	Weight per cent initial weight	100.0	102.8	104.9	104.9
	Moisture per cent	4.68	8.51	8.66	8.81
	Sucrose per cent	84.17	84.51	83.86	85.45
	Reducing sugars per cent	10.54	11.15	11.34	9.39
	Colour of N/2 gur solution**	477	388	383	433

** Colour was determined as indicated under table 1.

The composition of gur cubes initially and at the end of the experiment was determined. The data are presented in table 11. At 58 per cent relative humidity, the moisture content of the gur cubes did not change during the 30 days of the experiment. At the higher humidity of 72.5 per cent, it increased, and this appears to have caused a collapse of the cubes at the higher pressures.

Table 11

Effect of pressure on chemical composition of gur at room temperature (average 31°C) and different relative humidities (Results in columns 5, 6 and 7 expressed on moisture-free basis)

Relative humidity	Pressure per cm^2	Time of analysis	Moisture per cent	Colour*	Sucrose per cent	Reducing sugars per cent
58 per cent	0 g	Initial	4.14	495	83.66	10.59
		After 30 days	3.80	543	82.12	11.14
	35 g	Initial	4.00	485	81.60	10.68
		After 30 days	3.86	553	81.74	11.61
	70 g	Initial	3.75	483	81.39	10.78
		After 30 days	4.59	528	82.70	11.45
	105 g	Initial	4.33	454	81.56	10.87
		After 30 days	3.93	541	80.23	11.87
72.5 per cent	0 g	Initial	4.08	500	82.96	10.58
		After 30 days	5.80	517	80.85	11.13
	35 g	Initial	4.01	500	81.94	10.78
		After 30 days	8.11	559	82.22	11.56
	70 g	Initial	3.37	492	79.79	10.50
		After 30 days	4.73	546	78.35	11.53
	105 g	Initial	4.43	502	81.66	10.88
		After 30 days	5.69	575	78.17	11.77

* Colour was determined as indicated under table 1.

Changes in sucrose and reducing sugars were negligible under all the pressures, and all the cubes darkened in colour over the period of the experiment (A.S. Sastry and J.P. Bajpai).

2. The relationship between the chemical constituents of gur and spoilage in stored gur

i) Effect of maturity in the different varieties on the keeping quality of gur

To study the influence of maturity in the different cane varieties on the keeping quality of gur, gur was prepared from Co.951 and Co.997 during three periods, viz. beginning of January, middle of February and end of March, 1961, packed in gunny bags, and stored in a godown under Lucknow conditions. The temperature and humidity in this godown recorded by a thermo-hygrograph (table 12) ranged from 30.5 to 32°C and 78 to 84 per cent respectively. The highest humidities prevailed during August.

Table 12

Temperature and humidity in the Lucknow godown

Period	Average temperature °C	Average relative humidity per cent
From 24th April to 26th July 1961	31.9	77.8
From 27th July to 28th August 1961	30.5	83.7
From 29th August to 6th October 1961	30.4	81.8

Samples were drawn at periodic intervals and analysed for moisture, sucrose, reducing sugars, colour and pH. Weight changes of gur were also recorded at periodic intervals.

The data (table 13) show that all the gur samples absorbed considerable amounts of moisture and suffered weight losses. From the point of view of losses in weight, gur prepared from Co.997 was better than that from Co.951 at all stages of maturity. It also contained more sucrose and less reducing sugars generally than the gur from Co.951. Severe inversion losses occurred in all the gur samples. Most of the samples darkened in colour. Some became lighter afterwards due to draining out of molassine portions (A.S. Sastry and A.K. Ghosh).

ii) Influence of clarificants on the keeping quality of gur

To study this aspect, gur was prepared in the laboratory from the cane variety B.O.17 using lime, deola (Hibiscus ficulneus), bhindi (Abelmoshus esculentus), sukhlai (Kydia calycina) and no clarificant. The keeping quality of these samples is being studied (A.S. Sastry and A.K. Ghosh).

iii) Influence of chemical constituents and additives on the keeping quality of gur

To study the influence of chemical constituents on the keeping quality of gur, gur of various compositions having an excess or deficiency of particular constituents was specially prepared under controlled conditions during the 1961 season. For this, sugarcane juice was boiled in a laboratory pan, the contents were divided into two lots at the striking point of the gur and the requisite chemical compound (as indicated in the appropriate table) was added to one of them. The gur was cast into moulds of 5 cm x 5 cm x 1.25 cm size. After drying for a week they were kept in sealed bottles. The chemical compounds used were magnesium sulphate, sucrose and glucose. Two sets of gur blocks were prepared for each constituent.

The keeping quality of the gur samples was determined as follows. The above gur blocks were weighed and then kept in a desiccator at 40°C and 90 per cent relative humidity for exactly 24 hours. The increase in weight expressed as a percentage of the initial weight was taken as a measure of the bad keeping quality of gur.

The chemical composition of the gur samples prepared with and without the addition of chemicals was determined and the means of the readings on the two sets of cubes are presented in tables 14, 15 and 16.

The addition of magnesium sulphate increased the moisture content of gur and made it lighter in colour. There was no marked change in other constituents. The keeping quality of gur was adversely affected (table 14).

Addition of sucrose increased the moisture content of gur slightly and made it lighter coloured. There was not much change in other constituents. The keeping quality of gur was improved (table 15).

Table 13

Effect of maturity in two cane varieties on the chemical composition of gur during storage (all results except moisture expressed on moisture-free basis)

Particulars of gur	Constituents analysed	Initial 24th June '61	Analysed on 26th July, 1961	28th August, 1961	6th October, 1961
Prepared from Co.951 between 5th to 7th January, 1961	Weight per cent initial weight	100.0	60.74	39.19	0.00
	Moisture per cent	4.50	11.37	+	+
	Sucrose per cent	73.91	74.91	+	+
	Reducing sugars per cent	11.06	12.68	+	+
	Colour of N/2 gur* solution	712	801	+	+
Prepared from Co.997 between 9th to 12th January, 1961	Weight per cent initial weight	100.0	95.00	35.50	0.00
	Moisture per cent	4.90	11.19	9.49	+
	Sucrose per cent	83.49	75.66	80.56	+
	Reducing sugars per cent	10.34	12.25	9.49	+
	Colour of N/2 gur* solution	504	698	855	+
Prepared from Co.951 between 15th to 17th February, 1961	Weight per cent initial weight	100.0	89.09	54.66	19.45
	Moisture per cent	4.16	13.33	18.03	12.38
	Sucrose per cent	82.87	75.22	70.45	73.57
	Reducing sugars per cent	10.37	17.49	18.03	17.96
	Colour of N/2 gur* solution	370	485	322	256
Prepared from Co.997 between 22nd to 23rd February, 1961	Weight per cent initial weight	100.0	85.51	61.29	35.51
	Moisture per cent	2.62	12.16	11.38	10.42
	Sucrose per cent	82.15	74.68	80.58	79.42
	Reducing sugars per cent	9.91	19.85	11.38	12.47
	Colour of N/2 gur* solution	271	353	370	424
Prepared from Co.951 between 23rd to 29th March, 1961	Weight per cent initial weight	100.0	73.72	39.19	27.74
	Moisture per cent	3.71	10.67	13.90	11.74
	Sucrose per cent	77.70	73.88	76.09	87.44
	Reducing sugars per cent	10.71	18.04	13.90	8.85
	Colour of N/2 gur* solution	431	392	623	470
Prepared from Co.997 between 30th March to 1st April, 1961	Weight per cent initial weight	100.0	93.4	58.99	31.71
	Moisture per cent	2.60	10.60	13.77	13.42
	Sucrose per cent	80.90	82.32	78.18	81.75
	Reducing sugars per cent	10.06	11.36	13.77	10.35
	Colour of N/2 gur* solution	379	447	483	263

+ Sample inadequate for analysis.
* Colour was determined as indicated under table 1.

Table 14

Effect of addition of magnesium sulphate (0.25 g magnesium per litre of juice) on the chemical composition and keeping quality of gur

Particulars	Control	Magnesium sulphate added
Moisture per cent	6.27	8.83
Magnesium per cent*	0.057	0.180
Pol per cent*	82.56	82.02
Reducing sugars per cent*	7.77	8.09
Colour	751	568
pH	5.35	5.3
Keeping quality+	5.87	6.90

* Expressed on moisture-free basis.
\+ Increase in weight of gur per cent initial weight after 24 hours under 90 per cent relative humidity and 40°C temperature.

Table 15

Effect of addition of sucrose (15 g per litre of juice) on the chemical composition and keeping quality of gur

Particulars	Control	Sucrose added
Moisture per cent	5.95	7.48
Sucrose per cent*	85.76	88.18
Reducing sugars per cent*	7.34	6.52
Colour	510	412
pH	5.15	5.05
Keeping quality+	8.45	5.50

* Expressed on moisture-free basis.
\+ Increase in weight per cent initial weight after 24 hours under 90 per cent relative humidity and 40°C temperature.

Addition of glucose slightly improved the colour of gur. Other constituents did not change much. The keeping quality became worse (table 16).

Table 16

Effect of addition of Glucose (7.5 g per litre of juice) on the chemical composition and keeping quality of gur

Particulars	Control	Glucose added
Moisture per cent	6.02	5.32
Pol per cent*	84.37	83.44
Reducing sugars per cent*	6.51	10.70
Colour	729	642
pH	4.85	4.88
Keeping quality+	7.34	9.96

* Expressed on moisture-free basis.
\+ Increase in weight per cent initial weight after 24 hours under 90 per cent relative humidity and 40°C temperature.

During 1962 season, gur cubes with an excess or deficiency of the following compounds were prepared.

1. Magnesium sulphate, potassium sulphate and sodium sulphate.
2. Sodium hydrosulphite (Hydros).
3. Asparagine.

The keeping quality of these cubes is being studied to find out the precise influence of these constituents (A.S. Sastry and J.P. Bajpai).

iv) Designing and testing of suitable godowns

(a) For large-scale storage.- In the light of the results of experiments conducted in the Scheme on gur storage, a godown suitable for storing about 50 metric tons of gur has been designed by the Agricultural Engineer and is described under "Agricultural Engineering".

(b) For small-scale storage in villages and small growers' co-operatives.- An underground godown for storage of gur has been designed by the Agricultural Engineer and is described under "Agricultural Engineering".

Technical programme for 1962-63

1. Elucidation of the exact physical conditions causing deterioration of gur in storage.

   i) Effect of pressure and chemical composition on the keeping quality of gur.

2. The relationship between the chemical constituents of gur and spoilage in stored gur.

   i) Influence of maturity in different varieties on the keeping quality of gur.

   ii) Influence of clarificants on the keeping quality of gur.

   iii) Influence of chemical constituents and additives on the keeping quality of gur, : a) ash constituents, b) hydros, c) nitrogenous constituents.

3. Elucidation of effects of smoke on the preservation of gur.

4. Designing and testing of a suitable godown.

   i) for large-scale storage.

   ii) for small-scale storage in villages and small growers' co-operatives.